



WHITE RIVER SHALE PROJECT

Detailed Development Plan • Oil Shale Tracts Ua and Ub • Volume I • 1980

**FINAL
DRAFT**



28064911
BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

CRAIG DISTRICT OFFICE
LIBRARY COPY
TN
537
-182
W55
1904
Crag
V.1

WHITE RIVER SHALE PROJECT

Detailed Development Plan • Oil Shale Tracts Ua and Ub • Volume I

FINAL
DRAFT

Section 1: Introduction
Section 2: Description of Project Area
Section 3: Description of Proposed Action

Prepared by Bechtel Incorporated • San Francisco • Job 14188 • November 1980

Several organizations have contributed to the content of this document.
These include:

AeroVironment Inc.
Bechtel Incorporated
Bio-Resources Inc.
Phillips Petroleum Company
Sohio Petroleum Company
Sunoco Energy Development Co.
The Cleveland-Cliffs Iron Company
Utah State University
VTN Consolidated, Inc.

Each entity has contributed significantly in its own area of specialization,
and each deserves credit for technical content. The cooperation and hard
work of all parties is sincerely appreciated.

CONTENTS

<u>Section</u>		<u>Page</u>
1	INTRODUCTION	1-1
1.1	Contents of the Detailed Development Plan	1-1
1.2	The Oil Shale Prototype Program	1-4
1.3	Lease Issuance and Status	1-6
1.4	The White River Shale Project	1-7
1.4.1	Project Organization	1-7
1.4.2	Tracts Ua and Ub	1-8
1.4.3	Project Development	1-15
1.5	Exploration and Baseline Data Collection	1-22
1.5.1	Exploration Program	1-22
1.5.2	Baseline Data Collection	1-23
1.6	Summary of Costs	1-24
	References — Section 1	1-25
2	DESCRIPTION OF PROJECT AREA	2-1
2.1	Introduction	2-1
2.2	Geology and Soils	2-2
2.2.1	Physiography	2-2
2.2.2	Geologic History	2-6
2.2.3	Stratigraphy	2-6
2.2.4	Structural Geology	2-20
2.2.5	Geologic Hazards	2-21
2.2.6	Mineral Resources	2-21
2.2.7	Soils	2-25
2.3	Water Resources	2-34
2.3.1	Surface Water	2-34
2.3.2	System Interactions	2-56
2.3.3	Groundwater	2-63

<u>Section</u>		<u>Page</u>
(2)	2.4 Air Resources	2-99
	2.4.1 Climatology	2-99
	2.4.2 Meteorology	2-107
	2.4.3 Air Quality	2-119
	2.4.4 Radiation	2-128
	2.4.5 Sound Levels	2-129
	2.5 Biological Resources	2-130
	2.5.1 Terrestrial Vegetation	2-130
	2.5.2 Microorganisms	2-145
	2.5.3 Terrestrial Invertebrates	2-146
	2.5.4 Terrestrial Vertebrates	2-148
	2.5.5 Aquatic Systems	2-164
	2.5.6 Ecological Interrelationships	2-169
	2.6 Historical, Prehistoric, and Paleontological Resources	2-196
	2.6.1 Historic Resources	2-196
	2.6.2 Prehistoric Resources	2-200
	2.6.3 Paleontological Resources	2-204
	2.7 Aesthetics	2-209
	2.7.1 The Regional Aesthetic Setting	2-209
	2.7.2 The Ridgetop-Basin Landscape Unit	2-209
	2.7.3 The Canyon Landscape Unit	2-210
	2.7.4 The White River Landscape Unit	2-111
	References — Section 2	2-213
3	DESCRIPTION OF THE PROPOSED ACTION	3-1
	3.1 Introduction	3-1
	3.2 Objectives	3-2
	3.2.1 New Energy Sources	3-2
	3.2.2 Resource Recovery	3-2
	3.2.3 Environmental Protection	3-2
	3.3 Summary and Schedule of Project Development	3-3
	3.3.1 Introduction	3-3

<u>Section</u>		<u>Page</u>
(3)	3.3.2 Overall Development Schedule	3-3
	3.3.3 Exploratory, Baseline, and Preliminary Studies	3-4
	3.3.4 Layout of Facilities	3-7
	3.3.5 Mining	3-9
	3.3.6 Feed Preparation and Transportation	3-10
	3.3.7 Retorting	3-11
	3.3.8 Gas and Oil Processing	3-12
	3.3.9 Soils Handling	3-12
	3.3.10 Processed and Raw Shale Disposition	3-12
	3.3.11 Solid Waste Disposal	3-12
	3.3.12 Support Facilities and Requirements	3-13
	3.3.13 Ancillary Facilities and Maintenance	3-13
	3.3.14 Water Supply and Facilities	3-13
	3.3.15 Wastewater Management Plan	3-13
	3.3.16 Corridor Planning	3-13
	3.3.17 Product Transport	3-14
	3.3.18 By-Product Plan	3-14
	3.3.19 Construction Plan	3-14
	3.3.20 Operations Manpower	3-16
	3.3.21 Decommissioning-Abandonment Plan	3-16
3.4	Layout of Facilities	3-17
	3.4.1 General	3-17
	3.4.2 Site Access	3-18
	3.4.3 Site Preparation	3-18
	3.4.4 Water Supply	3-23
	3.4.5 Mine Shaft Locations	3-23
	3.4.6 Oil Shale Handling	3-23
	3.4.7 Process and Support Facilities	3-24
	3.4.8 Processed Shale Disposal	3-25
3.5	Mining	
	3.5.1 Mine Development Program	3-26

<u>Section</u>		<u>Page</u>
(3)	3.5.2 Mine Description	3-32
	3.5.3 Mine Safety	3-40
	3.5.4 Vegetation Removal Program	3-42
	3.5.5 Mine Wastewater Control	3-42
	3.5.6 Mine Air Emission Control	3-42
	3.5.7 Mine Noise Control	3-44
3.6	Feed Preparation and Material Handling	3-45
	3.6.1 Feed Specification	3-45
	3.6.2 Phase I Operations	3-46
	3.6.3 Phase II Operations	3-52
	3.6.4 Phase III Operations	3-58
3.7	Retorting	3-59
	3.7.1 General Retorting Description	3-59
	3.7.2 Vertical-Type Direct Heated Retort	3-62
	3.7.3 Vertical-Type Indirect Heated Retort	3-66
	3.7.4 Fines-Type Retorts	3-69
	3.7.5 Pollution Control Program	3-72
3.8	Gas and Oil Processing	3-73
	3.8.1 Raw Shale Oil Treatment	3-73
	3.8.2 Retort Gas Treatment	3-73
	3.8.3 Pollution Control Program	3-74
3.9	Soils Handling	3-75
	3.9.1 Excavation and Disposal of Excess Material	3-75
	3.9.2 Regulatory Requirements	3-75
	3.9.3 Topsoil for Revegetation	3-76
3.10	Processed Shale and Fines Disposition	3-77
	3.10.1 Introduction	3-77
	3.10.2 Characteristics of Processed Shale	3-77
	3.10.3 The Disposal Area	3-80
	3.10.4 Phase I Disposal Plan	3-81
	3.10.5 Phase II and III Disposal Plan	3-86

<u>Section</u>	<u>Page</u>
(3) 3.11 Solid Waste Disposal	3-91
3.11.1 Solid Waste Sources and Types	3-91
3.11.2 Waste Collection	3-91
3.11.3 Waste Disposal	3-92
3.12 Utilities and Support Facilities	3-96
3.12.1 Electric Power	3-96
3.12.2 Steam Requirements	3-98
3.12.3 Boiler Plant	3-100
3.12.4 Fuel Requirements	3-101
3.12.5 Cooling Tower	3-101
3.12.6 Cooling Water Pumps	3-101
3.12.7 Air Systems	3-101
3.12.8 Interconnecting Lines	3-101
3.12.9 Product Loading	3-102
3.12.10 Chemical Handling	3-102
3.13 Ancillary Facilities and Maintenance	3-103
3.13.1 Relief and Blowdown	3-103
3.13.2 Plant Drainage	3-103
3.13.3 Tankage	3-105
3.13.4 Water Storage Ponds	3-106
3.13.5 Fire Prevention and Control Plan	3-106
3.13.6 Medical Facilities	3-108
3.13.7 Buildings and Parking	3-109
3.13.8 Mobile Equipment	3-109
3.14 Water Supply Facilities	3-110
3.14.1 Water Supply Development Program	3-110
3.14.2 Phase I System	3-114
3.14.3 Phase II and III System	3-116
3.14.4 Water Treatment	3-118
3.15 Wastewater Management Plan	3-119
3.15.1 Sequence of Development	3-119
3.15.2 Wastewater Sources and Characteristics	3-120

<u>Section</u>		<u>Page</u>
(3)	3.15.3 Wastewater Collection	3-125
	3.15.4 Wastewater Treatment System	3-127
	3.15.5 Wastewater Reuse	3-128
3.16	Corridor Planning	3-130
	3.16.1 Corridor Development Program	3-130
	3.16.2 Access Roads	3-130
	3.16.3 Power Lines	3-132
	3.16.4 Water Supply Lines	3-132
3.17	Product Transport	3-133
3.18	By-Product Plan	3-134
3.19	Construction Plan	3-135
	3.19.1 Construction Phases	3-135
	3.19.2 Construction Manpower Schedule	3-136
	3.19.3 Campsite Development	3-138
	3.19.4 Site Access	3-139
	3.19.5 Schedule of Field Operations	3-140
	3.19.6 Construction Pollution Control	3-142
3.20	Operations Manpower	3-146
3.21	Decommissioning-Abandonment Plan	3-148
	3.21.1 Decommissioning	3-148
	3.21.2 Abandonment	3-150
	References — Section 3	3-151
4	PLANNED ENVIRONMENTAL PROTECTION PROCEDURES	4-1
4.1	Introduction	4-1
4.2	Air Pollution Control	4-3
	4.2.1 Regulations, Standards, and Guidelines	4-3
	4.2.2 Air Pollutant Emission Inventory	4-6
	4.2.3 Air Pollution Control Plan	4-8
	4.2.4 Noise Pollution Control	4-21
4.3	Solid Waste Disposal Plan	4-30
	4.3.1 Regulations, Standards, and Guidelines	4-30
	4.3.2 Waste Sources	4-31

<u>Section</u>		<u>Page</u>
(4)	4.3.3 Waste Handling, Storage, and Disposal Systems	4-35
	4.3.4 Summary of Disposal Plan	4-38
4.4	Water Pollution Control	4-40
	4.4.1 Protection of Existing Water Resources	4-40
	4.4.2 Regulations, Standards, and Guidelines	4-41
	4.4.3 Removal of Oil and Other Hazardous Materials	4-44
	4.4.4 Pesticides and Herbicides Use Plan	4-47
4.5	Water Drainage and Erosion Control	4-49
	4.5.1 Design Rationale	4-49
	4.5.2 Drainage Control Plan	4-52
	4.5.3 Surface and Subsurface Drainage Interaction	4-60
4.6	Disturbed Area Rehabilitation and Revegetation	4-63
	4.6.1 Rehabilitation Plan for Disturbed Areas	4-63
	4.6.2 Revegetation Plan for Processed Shale	4-67
4.7	Fish and Wildlife Management Plan	4-81
	4.7.1 Avoidance or Minimization of Damage to Fish and Wildlife Habitat	4-81
	4.7.2 Restoration of Unavoidably Destroyed or Damaged Habitat	4-83
	4.7.3 Alternative Habitat	4-83
	4.7.4 Human Activities	4-90
	4.7.5 White River Dam	4-90
	4.7.6 Relation Between the Mitigation and Monitoring Plans	4-91
4.8	Protection of Historic, Prehistoric, and Paleontological Resources	4-92
	4.8.1 Resource Inventory	4-92
	4.8.2 Protection Program	4-92
4.9	Aesthetic Value Considerations	4-96
4.10	Fire Prevention and Control	4-98
4.11	Oil and Hazardous Materials Spill Contingency Plan	4-99

<u>Section</u>		<u>Page</u>
(4)	4.11.1 Normal Extraction and Tank Farm Area Spills	4-99
	4.11.2 Transportation-Related Spills	4-101
4.12	Prevention of Hazards to Public Health and Safety	4-106
	4.12.1 Environmental Regulations	4-106
	4.12.2 Mine Portals and Shafts	4-106
	4.12.3 Process Area and Tank Farm	4-109
	4.12.4 Plant Access Roads	4-109
	4.12.5 Processed Shale Disposal	4-109
	4.12.6 Water and Wastewater Impoundments	4-109
	4.12.7 Product and Freshwater Pipelines	4-110
	4.12.8 Construction Activities	4-110
	4.12.9 Carcinogens	4-110
	References — Section 4	4-112
5	ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION AFTER MITIGATION	5-1
5.1	Introduction	5-1
5.2	Effects on Air Resources	5-2
	5.2.1 Introduction	5-2
	5.2.2 Description of the Modeling Approach	5-4
	5.2.3 Inputs to the Modeling Analysis	5-9
	5.2.4 Predicted Annual Average Impacts	5-18
	5.2.5 Predicted Worst-Case Short-Term Impacts	5-27
	5.2.6 Project Impacts on Pristine Areas	5-35
	5.2.7 Modeling Summary	5-37
	5.2.8 Noise Impacts	5-37
5.3	Effects on Water Resources	5-46
	5.3.1 Phase I	5-46
	5.3.2 Phases II and III	5-50
	5.3.3 Decommissioning Period	5-55
5.4	Effects on Biological Resources	5-56
	5.4.1 Potential Impacts from Construction and Operation	5-56

<u>Section</u>		<u>Page</u>
(5)	5.4.2 Response of Major Biotic Groups to Impacts	5-64
	5.4.3 Changes in Ecosystem Structure and Function	5-74
	5.4.4 Effects of the White River Reservoir	5-76
5.5	Effects on Soils and Geology	5-78
	5.5.1 Phase I	5-78
	5.5.2 Phases II and III	5-84
5.6	Effects on Historic, Prehistoric, and Paleontological Resources	5-87
	5.6.1 Phase I	5-87
	5.6.2 Phase II	5-89
	5.6.3 Phase III	5-89
	5.6.4 Off-Tract Impacts	5-89
5.7	Effects on Aesthetics	5-91
	5.7.1 Introduction	5-91
	5.7.2 The Regional Aesthetic Setting	5-91
	5.7.3 The Ridgetop-Basin Landscape Unit	5-92
	5.7.4 The Canyon Landscape Unit	5-97
	5.7.5 The White River Landscape Unit	5-97
	5.7.6 Summary	5-100
5.8	Environmental Effects of Decommissioning-Abandonment	5-101
	5.8.1 Decommissioning	5-101
	5.8.2 Abandonment	5-101
	References — Section 5	5-103
6	MONITORING PROGRAM	6-1
6.1	Objectives and Rationale of the Monitoring Program	6-1
6.2	Air Monitoring	6-3
	6.2.1 Overview of the Air Monitoring Program	6-5
	6.2.2 Group I Measurements: Long-Term Air Quality Evolution	6-6
	6.2.3 Group II Measurements: Direct Impact of Ua and Ub Emissions	6-13

<u>Section</u>		<u>Page</u>
(6)	6.2.4 Group III Measurements: Area Impact	6-15
	6.2.5 Group IV Measurements: Short-Term Intensive Studies	6-17
	6.2.6 Measurement Methods	6-18
	6.2.7 Data Analysis	6-23
6.3	Water Monitoring	6-26
	6.3.1 Surface Water	6-26
	6.3.2 Groundwater	6-37
	6.3.3 Water within the Unsaturated (Vadose) Zone	6-44
	6.3.4 Special Studies	6-47
	6.3.5 Data Treatment	6-48
	6.3.6 Quality Assurance Program	6-52
6.4	Solid Waste Monitoring	6-55
	6.4.1 Monitoring Parameters and Methodology	6-55
	6.4.2 Rationale	6-56
	6.4.3 Data Handling	6-56
6.5	Noise Monitoring	6-58
	6.5.1 Monitoring Parameters	6-58
	6.5.2 Monitoring Methodology	6-59
	6.5.3 Rationale	6-60
	6.5.4 Data Handling	6-61
6.6	Biota Monitoring	6-62
	6.6.1 Rationale	6-62
	6.6.2 Monitoring Parameters	6-64
	6.6.3 Quality Assurance	6-88
	6.6.4 Monitoring Model Construction	6-89
	6.6.5 Monitoring Manual	6-93
	References — Section 6	6-94
7	ALTERNATIVES AND SELECTION RATIONALE	7-1
	7.1 Introduction	7-1
	7.2 Selection Criteria	7-2
	7.3 Selection Rationale	7-4

<u>Section</u>		<u>Page</u>	
(7)	7.4	Layout of Facilities	7-5
	7.4.1	Overall Site Requirements	7-5
	7.4.2	Mine Shafts	7-5
	7.4.3	Processed Shale Disposal Area	7-5
	7.4.4	Material Handling Facilities	7-6
	7.4.5	Water Management System	7-6
	7.4.6	Process and Other Facilities	7-7
	7.4.7	Soils Handling	7-7
	7.4.8	Access Corridors	7-7
	7.5	Mining	7-8
	7.5.1	Surface Mining	7-8
	7.5.2	Underground Mining	7-10
	7.5.3	In-Situ Processing	7-14
	7.5.4	Haulage Systems	7-17
	7.6	Feed Preparation Alternatives	7-18
	7.6.1	Primary Crushing	7-18
	7.6.2	Coarse Raw Shale Storage and Reclaiming	7-20
	7.6.3	Secondary Crushing	7-21
	7.6.4	Material Handling	7-21
	7.6.5	Dust Suppression	7-23
	7.7	Retorting	7-24
	7.7.1	General Description	7-24
	7.7.2	Retorting Processes	7-27
	7.7.3	Processed Shale Cooling	7-31
	7.8	Upgrading	7-35
	7.8.1	Range of Upgrading Alternatives	7-35
	7.8.2	No Upgrading	7-37
	7.8.3	Mild Upgrading	7-38
	7.8.4	Moderate Upgrading	7-39
	7.8.5	Severe Upgrading	7-39
	7.8.6	Upgrading Summary	7-40
	7.8.7	Support Processes	7-45
	7.8.8	Selection Rationale	7-47

<u>Section</u>		<u>Page</u>
(7)	7.9 Handling of Excess Soils	7-49
	7.10 Processed Shale Disposition	7-50
	7.10.1 Introduction and Overview	7-50
	7.10.2 Characteristics of Processed Shale	7-50
	7.10.3 Possible Disposal Sites	7-51
	7.10.4 Phase I Disposal	7-55
	7.10.5 Phase II and III Disposal	7-57
	7.10.6 Abandonment	7-65
	7.11 Solid Waste Disposal	7-67
	7.11.1 Landfill in Processed Shale Disposal Area	7-67
	7.11.2 Separate Landfill	7-68
	7.11.3 Combination of Incineration and Landfill	7-68
	7.11.4 Evaluation of Alternatives	7-68
	7.12 Utilities and Support Facilities	7-70
	7.12.1 Electric Power Supply	7-70
	7.12.2 Steam Requirements and Supply	7-72
	7.12.3 Cooling Systems	7-73
	7.12.4 Evaluation of Alternatives	7-73
	7.13 Ancillary Facilities and Maintenance	7-75
	7.13.1 Drainage System	7-75
	7.13.2 Plant Sewer Systems	7-76
	7.14 Water Supply Facilities	7-78
	7.14.1 Water Supply Development Program	7-79
	7.14.2 Evaluation of Alternatives	7-82
	7.14.3 Water Rights	7-84
	7.14.4 Raw Water Delivery System	7-84
	7.14.5 Water Treatment	7-86
	7.14.6 Selection Rationale	7-87
	7.15 Wastewater Management Plan Alternatives	7-88
	7.15.1 Collection Alternatives	7-88
	7.15.2 Treatment Alternatives	7-89
	7.15.3 Reuse Alternatives	7-91

<u>Section</u>	<u>Page</u>
(7) 7.16 Corridor Planning	7-95
7.16.1 Selection Criteria	7-95
7.16.2 Access Highways	7-96
7.16.3 Power Lines	7-100
7.16.4 Water Supply Lines	7-101
7.17 Product Transport	7-104
7.17.1 Alternative Product Pipeline Routes	7-104
7.17.2 Alternative Markets for Upgraded Shale Oil	7-107
7.18 By-Product Plan	7-108
7.18.1 Coke	7-108
7.18.2 Ammonia	7-108
7.18.3 Sulfur	7-108
7.18.4 Surplus Gas or Power	7-110
7.18.5 Heavy Unrefined Oil	7-110
7.18.6 Liquefied Petroleum Gas	7-110
7.19 Construction Plan	7-111
7.19.1 Alternative Schedules	7-111
7.19.2 Alternative Campsite	7-111
7.19.3 Access	7-111
7.19.4 Alternative Evaluation	7-112
7.19.5 Selection Rationale	7-113
References — Section 7	7-114

ILLUSTRATIONS

<u>Figure</u>	<u>Page</u>
1.4-1 Location of Tracts Ua and Ub	1-10
1.4-2 White River Shale Project Schedule	1-17
2.2-1 Physiographic Map of the Uinta Basin Region	2-3
2.2-2 Slope Gradients Map, Tracts Ua and Ub	2-7
2.2-3 Geologic Map of Oil Shale Tracts Ua and Ub	2-11
2.2-4 Geologic Cross Section Through Oil Shale Tract Ua	2-13
2.2-5 Geologic Cross Section Through Oil Shale Tract Ub	2-15
2.2-6 Subsurface Structural Contour Map of the Mahogany Marker Bed, Tracts Ua and Ub	2-17
2.2-7 Mineral Resources of the Uinta Basin	2-23
2.2-8 Soils Map of Oil Shale Tracts Ua and Ub	2-27
2.3-1 Monitoring Locations of Surface Water	2-35
2.3-2 Mean Daily Streamflow of White River Near Watson	2-37
2.3-3 Mean Daily Streamflow of Evacuation Creek Near Watson	2-41
2.3-4 Typical Borehole Electric Log of Rock Formations Beneath Site	2-65
2.3-5 Structural Contours on Top of Bird's Nest Aquifer, S.E. Uinta Basin	2-67
2.3-6 Monitoring Locations of Bedrock Aquifers	2-69
2.3-7 Monitoring Locations of the Alluvial Aquifers	2-71
2.3-8 Contour Map of the Piezometric Surface of Bird's Nest Aquifer, March 1975	2-75
2.4-1 Measurement Stations on Tracts Ua and Ub from 1975 to 1979	2-100
2.4-2 Normal Sea Level Pressure and Temperature in January and July	2-101
2.4-3 Diurnal Variation of Mean Hourly Temperatures at Site A6 from 1975 to 1979	2-105

<u>Figure</u>	<u>Page</u>
2.4-4 Average Monthly Maximum and Minimum and Monthly Mean Temperature at Site A6 from 1975 to 1979	2-105
2.4-5 Diurnal Variation of Mean Relative Humidity at Site A6 in January and July from 1975 to 1979	2-106
2.4-6 Diurnal Variation of Mean Net Thermal Radiation at Site A6 in January and July from 1975 to 1979	2-106
2.4-7 Typical Air Flow Patterns on Tracts Ua and Ub from 1975 to 1979	2-109
2.4-8 Diurnal Variation of Mean Wind Speed at Site A6 in January and July from 1975 to 1979	2-111
2.4-9 Monthly Mean and Peak Wind Speeds and Their Standard Deviations at Site A6 from 1975 to 1979	2-111
2.4-10 Directional Wind Roses	2-113
2.4-11 Diurnal Variation of the Mean ΔT at Site A6 in January and July from 1977 to 1979	2-118
2.4-12 Monthly Average Ozone at Site A6 from February 1975 to December 1979	2-124
2.4-13 Diurnal Variation of Mean Ozone Concentrations at Site A6 in January and July from 1975 to 1979	2-124
2.5-1 Vegetation Map	2-137
2.5-2 Sagebrush-Greasewood Type of Southam Canyon (with Juniper in Background)	2-139
2.5-3 Juniper Vegetation Type at Higher Elevations	2-139
2.5-4 Shadscale Vegetation on Hills (Sagebrush-Greasewood in Foreground)	2-140
2.5-5 Riparian Vegetation Type Along the White River	2-140
2.5-6 Deer Migration Routes and Wintering Areas	2-151
2.5-7 Livestock Grazing Allotments	2-155
2.5-8 Mean Annual Precipitation for Water Years 1974-75 to 1978-79	2-170
2.5-9 Mean Monthly Precipitation for Water Years 1974-75 to 1978-79	2-170
2.5-10 Mean Annual Sagebrush Stem Growth Related to Fall-Winter Precipitation	2-175
2.5-11 Mean Annual Herbaceous Plant Production Related to Spring Precipitation	2-176

<u>Figure</u>	<u>Page</u>
2.5-12 Mean Annual and Monthly Bird Species Richness and Abundance for the Four Habitat Types, 1975-1979	2-183
2.5-13 Mean Annual Bird Abundance Related to the Total Precipitation, 1975-1979	2-183
2.5-14 Rodent Density and Species Richness Related to Soil Infiltration Rate and Percent Moisture at Saturation of the Soil	2-184
2.5-15 Mean Rodent Abundance Related to Mean Herbaceous Plant Production	2-185
3.3-1 White River Shale Project Schedule	3-5
3.3-2 Area Map	3-7
3.4-1 Overall Site Plan	3-19
3.4-2 Process Area Plot Plan	3-21
3.5-1 Mine Production	3-27
3.5-2 Phase I Mine Layout	3-29
3.5-3 Phase III Mine Layout	3-31
3.5-4 General Site Plan	3-33
3.5-5 Phase I Ventilation Plan	3-35
3.5-6 Room-and-Pillar Two-Bench Mining System	3-36
3.6-1 Material Handling Flow Diagram, Phase I	3-47
3.6-2 Material Handling Flow Diagram, Phases II and III	3-53
3.7-1 Block Flow Diagram - Phase I Retorting	3-60
3.7-2 Block Flow Diagram - Phase II and III Retorting	3-61
3.7-3 Direct Heated (DH) Retorting System	3-64
3.7-4 Vertical-Type DH Retort	3-64
3.7-5 Indirect Heated (IH) Retorting System	3-67
3.7-6 Vertical-Type IH Retort	3-67
3.7-7 Fines-Type Retorting System	3-69
3.10-1 Section Drawing of Tract Ua	3-81
3.10-2 Processed Shale Disposal, Phase I	3-82
3.10-3 Contouring for Revegetation Program	3-85
3.10-4 Processed Shale Disposal, Phases II and III	3-89

<u>Figure</u>	<u>Page</u>
3.11-1 Solid Waste Disposal Schematic	3-93
3.14-1 White River Flow	3-112
3.15-1 Wastewater Management Schedule	3-119
3.15-2 Phase I Water and Wastewater Handling System	3-121
3.15-3 Phase II and III Water and Wastewater Handling System	3-123
3.16-1 Corridors to WRSP Site	3-131
3.19-1 Manpower Schedule	3-137
3.19-2 Schedule of Construction Operations	3-141
4.4-1 Overview of Wastewater Management Plan	4-45
4.5-1 Drainage Control Features	4-54
4.6-1 Map of Soils in the Tracts and Vicinity	4-73
4.6-2 Surface Modification and Vegetation on Processed Shale	4-78
4.7-1 Location of Disturbed and Alternative Habitats	4-85
5.2-1 Study Area with Respect to Existing and Proposed Class I Wilderness Areas	5-5
5.2-2 Plume Height in Complex Terrain	5-7
5.2-3 Receptor Grid for Phase I Impact Analysis	5-14
5.2-4 Receptor Grid for Phase III Impact Analysis	5-17
5.2-5 Isopleths of Phase I TSP Annual-Average Increments	5-19
5.2-6 Isopleths of Phase I SO ₂ Annual-Average Increments	5-20
5.2-7 Isopleths of Phase I NO ₂ Annual-Average Increments	5-21
5.2-8 Isopleths of Phase III TSP Annual-Average Increments	5-22
5.2-9 Isopleths of Phase III SO ₂ Annual-Average Increments	5-23
5.2-10 Isopleths of Phase III NO ₂ Annual-Average Increments	5-24
5.2-11 Plots of Predicted Worst-Case TSP 24-Hour Average Concentration Versus Distance for Phase I	5-29
5.2-12 Plots of Predicted Worst-Case SO ₂ 24-Hour Average Concentration Versus Distance for Phase I	5-30
5.2-13 Plots of Predicted Worst-Case TSP 24-Hour Average Concentration Versus Distance for Phase III	5-31
5.2-14 Plots of Predicted Worst-Case SO ₂ 24-Hour Average Concentration Versus Distance for Phase III	5-32

<u>Figure</u>		<u>Page</u>
5.4-1	Vegetation Distribution on Tracts Ua and Ub	5-57
5.7-1	Landscape Units for Evaluating Aesthetic Resources	5-93
6.2-1	Continuous Air Quality and Meteorological Measurement Sites on Tracts Ua and Ub	6-8
6.3-1	Surface Water Monitoring Sites	6-27
6.3-2	Existing Groundwater Monitoring Wells	6-39
6.6-1	Flow Models for Monitoring Nonreclaimed Areas	6-90
6.6-2	Flow Models for Monitoring Reclaimed Areas	6-91
7.5-1	A Typical Strip Mining System	7-9
7.5-2	A Typical Open-Pit Mine	7-12
7.5-3	Single-Pass Room-And-Pillar Mining	7-12
7.5-4	A Typical Longwall Slicing System	7-15
7.5-5	A Typical Block-Caving System	7-15
7.5-6	In-Situ Processing	7-16
7.6-1	Typical Roll Crusher	7-19
7.6-2	Double-Bucket Hoist for Large-Scale Deep-Lift Operation	7-22
7.7-1	Direct Heated (DH) Retorting System	7-24
7.7-2	Indirect Heated (IH) Retorting System	7-25
7.7-3	Simplified Diagrams and Brief Descriptions of Retorting Processes	7-29
7.8-1	Upgrading Alternatives	7-36
7.8-2	Processing the Raw Shale Oil to Produce Cracked Shale Oil	7-38
7.8-3	Processing the Raw Shale Oil to Produce Boiler Fuel Oil	7-39
7.8-4	Processing the Raw Shale Oil to Produce Refined Shale Oil	7-39
7.10-1	Canyon "G"	7-53
7.10-2	Fill Plan Starting at the North	7-58
7.10-3	Fill Plan Starting at the South	7-58
7.14-1	Alternative Water Sources	7-83
7.15-1	Wastewater Reuse Alternatives	7-93

<u>Figure</u>	<u>Page</u>
7.16-1 Corridors from Bonanza to Vernal	7-99
7.16-2 Water Supply Routes from Green River	7-102
7.17-1 Pipeline Routes for Upgraded Shale Oil	7-105
7.19-1 Alternative Campsite in Bonanza	7-112

TABLES

<u>Table</u>	<u>Page</u>
1.4-1 Properties of Raw Shale Oil	1-20
1.6-1 Estimated Capital and Operating Costs	1-24
2.2-1 Estimated and Measured Soil Properties Significant to Engineering Needs	2-30
2.2-2 Interpretations of Engineering Properties of Soils	2-31
2.3-1 Summary of Streamflow Records at White River Near Watson, Utah, Water Years 1975-1979 and Period of Record	2-39
2.3-2 Summary of Streamflow Records at Evacuation Creek Near Watson, Utah, Water Years 1975-1979	2-43
2.3-3 Summary of Streamflow Records at Southam Canyon Wash at Mouth, Near Watson, Utah, Water Years 1975-1979	2-44
2.3-4 Summary of Streamflow Records at Asphalt Wash Near Mouth, Near Watson, Utah, Water Years 1975-1979	2-46
2.3-5 Summary of Streamflow Records at Hells Hole Canyon Creek at Mouth, Near Watson, Utah, Water Years 1975-1979	2-47
2.3-6 Summary of Water Quality of the White River, October 1974-September 1979	2-49
2.3-7 State of Utah Numerical Standards for Protection of Beneficial Uses of Water	2-52
2.3-8 State of Utah Numerical Standards for Protection of Class 3C Water Use	2-53
2.3-9 Summary of Water Quality of Evacuation Creek, October 1974-September 1979	2-54
2.3-10 Summary of Water Quality of Southam Canyon, October 1974-September 1979	2-57
2.3-11 Summary of Water Quality of Asphalt Wash, October 1974-September 1979	2-59
2.3-12 Summary of Water Quality of Hells Hole Canyon, October 1974-September 1979	2-61

<u>Table</u>	<u>Page</u>
2.3-13 Summary of Aquifer Testing	2-73
2.3-14 Summary of Groundwater Quality for Bird's Nest, Upper, and Douglas Creek Aquifers, October 1974-September 1979	2-81
2.3-15 Summary of Alluvial Water Quality for White River Alluvium, January 1976-September 1977	2-85
2.3-16 Summary of Alluvial Water Quality for Evacuation Creek Alluvium, January 1976-September 1977	2-89
2.3-17 Summary of Alluvial Water Quality for Dry Washes Alluvium, January 1976-September 21, 1977	2-93
2.3-18 Summary of Alluvial Water Quality for Southam Canyon (AG-7), September 21, 1979	2-97
2.4-1 Average Monthly Wind Speeds and Prevailing Direction on Tracts Ua and Ub from 1975 to 1979	2-108
2.4-2 Relative Frequency Distribution of Diffusion Classes at Site A6 from June 1975 through December 1979	2-117
2.4-3 Percent Frequency Distribution of Stability by Season at Site A6 from 1977 to 1979	2-119
2.4-4 National Ambient Air Quality Standards for Gaseous Pollutants	2-120
2.4-5 One-Hour Ozone Readings at Site A6 from 1975 to 1979	2-122
2.4-6 Peak Pollutant Concentration Values Measured from 1975 to 1979	2-125
2.4-7 Annual Averages for the Gaseous Pollutants and Annual Geometric Mean for TSP from 1975 to 1979	2-125
2.4-8 Geometric Means and Maximum Daily Averages for Particulates at Site A6 from 1975 to 1979	2-126
2.4-9 Local Visual Range Values on Site A2 from 1975 to 1976	2-128
2.4-10 Average Nuclear Radiation Dosage at Tracts Ua and Ub During June 1975 through March 1979	2-129
2.5-1 Plant Species in Each of the Plant Communities	2-131
2.5-2 Average Spring Season Biomass Production of Annual Species on Tracts Ua and Ub	2-143
2.5-3 Comparison of Production of Perennial Shrubs, Trees, Forbs, and Late Maturing Annuals within the Four Vegetation Types	2-143

<u>Table</u>	<u>Page</u>
2.5-4 Percent of Plant Cover Observed on the Four Vegetation Types in Fall and Spring	2-144
2.5-5 Species Composition of Terrestrial Vertebrates on Tracts Ua and Ub	2-149
2.5-6 Nongame Bird Residency Status, Number of Species, and Abundance on Tracts Ua and Ub	2-160
2.5-7 Mean Dehydrogenase Activity in 1976	2-181
2.6-1 Prehistoric Resource Inventory	2-201
2.6-2 Paleontological Resource Inventory	2-206
3.5-1 Mining Operation Utility Requirements	3-40
3.7-1 Retorting Material Balance	3-62
3.7-2 Estimated Composition of Raw Shale Oil: Vertical-Type DH Retort	3-65
3.7-3 Estimated Composition of Low-Btu Gas: Vertical-Type DH Retort	3-65
3.7-4 Estimated Composition of Raw Shale Oil: Vertical-Type IH Retort	3-68
3.7-5 Estimated Composition of Low-Btu Gas: Vertical-Type IH Retort	3-68
3.7-6 Estimated Composition of Raw Shale Oil: Fines-Type Retort	3-71
3.7-7 Estimated Composition of High-Btu Gas: Fines-Type Retort	3-71
3.8-1 Sulfur Recovery from Product Gas	3-74
3.10-1 Physical Properties of Colorado Paraho-Processed Shale	3-79
3.12-1 Breakdown of Electric Power Demand	3-97
3.12-2 Estimated Electric Power Demands and Generation	3-97
3.13-1 Tankage Summary	3-105
3.13-2 Building Requirements	3-109
3.14-1 Phase I Water Requirements	3-114
3.14-2 Phase III Water Requirements	3-116
3.15-1 Wastewater Streams Summary	3-126
3.19-1 Campsite Utilities	3-139
3.20-1 Operations Manpower Requirements	3-147

<u>Table</u>	<u>Page</u>
4.2-1 Federal New Source Performance Standards	4-4
4.2-2 Federal Ambient Air Quality Standards	4-5
4.2-3 Limits of Significant Deterioration of Air Quality	4-7
4.2-4 Air Pollutant Emission Inventory - Phase I	4-9
4.2-5 Air Pollutant Emission Inventory - Phase III	4-13
4.2-6 Occupational Noise Regulations	4-22
4.2-7 Construction Noise Levels from Typical Untreated Equipment	4-23
4.2-8 Mining Noise Levels from Typical Untreated Equipment	4-24
4.2-9 Processing Noise Levels from Typical Untreated Equipment	4-24
4.3-1 Summary of Major Solid Wastes, Phase I	4-32
4.3-2 Summary of Major Solid Wastes, Phases II and III	4-33
4.4-1 Wastewater Sources	4-43
4.5-1 Approximate Disturbed Areas	4-50
4.5-2 Summary of Drainage Control Features	4-53
4.6-1 Chemical Properties of Oil Shale	4-70
4.6-2 Soils of the Processed Shale Disposal Site	4-75
4.8-1 Prehistoric Resource Inventory	4-93
4.12-1 Summary of Public Health and Safety Measures	4-107
5.2-1 Estimated Emissions from Project Operation	5-3
5.2-2 Particulate Fractions under 30 μ Diameter	5-12
5.2-3 Phase I Source Inventory	5-13
5.2-4 Phase III Source Inventory	5-15
5.2-5 Maximum Predicted Annual Average Concentrations, Locations, and Applicable Standards	5-25
5.2-6 Maximum Predicted 24-Hour Average Concentrations, Locations, and Applicable Standards	5-28
5.2-7 Projected Maximum Noise Levels at Bonanza Caused by Phase I Construction	5-40
5.2-8 Projected Maximum Noise Levels at Bonanza Caused by Phase II Construction	5-42

<u>Table</u>	<u>Page</u>
5.2-9 Projected Maximum Noise Levels at Bonanza During Phase II Operation and Phase III Construction	5-43
5.4-1 Grazing Utilization	5-68
5.5-1 Characteristics of Soils Affected by Oil Shale Development	5-79
5.7-1 Aesthetic Impacts: Ridgetop-Basin Landscape Unit	5-95
5.7-2 Aesthetic Impacts: Canyon Landscape Unit	5-98
5.7-3 Aesthetic Impacts: White River Landscape Unit	5-99
6.2-1 Continuous Air Quality and Meteorological Monitoring Program on Tracts Ua and Ub	6-7
6.2-2 Parameters Measured in Air Quality Monitoring Program	6-9
6.2-3 Air Quality Monitoring Program on Tracts Ua and Ub by Parameter	6-10
6.2-4 Air Quality Monitoring Program on Tracts Ua and Ub by Development Phase	6-11
6.2-5 Air Quality Measurement Methods and Frequency	6-19
6.3-1 Locations of Existing Streamflow Gauging Stations	6-29
6.3-2 Locations of Precipitation Gauging Stations	6-30
6.3-3 Parameters for Laboratory Analyses of Surface Water Quality for Tracts Ua and Ub	6-33
6.3-4 Existing Wells to be Used for Monitoring Groundwater Levels	6-38
6.3-5 Existing Wells to be Used for Monitoring Groundwater Quality	6-41
6.3-6 Monitoring Parameters for Laboratory Analysis of Groundwater Quality for Tracts Ua and Ub	6-43
6.6-1 Monitoring Parameters of Plant Condition and Stress	6-72
6.6-2 Aquatic Monitoring Sites	6-82
6.6-3 Physical Parameters of Aquatic Monitoring	6-83
7.7-1 Comparison of the Major Retorting Processes	7-28
7.8-1 Environmental Effects of Shale Oil Upgrading Schemes	7-43
7.8-2 Potential Upgrading Processes	7-48
7.11-1 Comparison of Solid Waste Disposal Alternatives	7-69
7.14-1 Phase III Water Requirements	7-79
7.17-1 Upgraded Shale Oil Pipeline Distance	7-106
7.18-1 By-Products of Upgrading Alternatives	7-109

Section 1

INTRODUCTION

1.1 CONTENTS OF THE DETAILED DEVELOPMENT PLAN

In accordance with Section 10 of the Federal Oil Shale Lease (Ref. 1-1), the White River Shale Project (WRSP) is required to prepare a Detailed Development Plan (DDP) for Tracts Ua and Ub located in northeast Utah adjacent to the White River. The plan must include "a schedule of the planning, exploratory, development, production, processing, and reclamation operations and all other activities to be conducted." In addition, submission of a description drawn in detail is necessary "to assure that the development plan, and lease operations thereunder, will meet and conform to the environmental criteria and controls incorporated in the lease." The lease in effect requires that the DDP conform to all federal, state, and local regulations and standards for air, water, and land quality, and that it include environmental safeguards and lease land rehabilitation. The DDP must be approved by the Mining Supervisor (Area Oil Shale Supervisor) before work is begun on the leased property.

The most probable plan for commercial oil shale production and processing includes underground mining, surface retorting, and export of the raw shale oil from the site for upgrading at an existing refinery (or refineries). A gross nominal production of 100,000 barrels per day of raw shale oil is ultimately expected from Tracts Ua and Ub at full commercial operation.

The DDP for the White River Shale Project is divided into seven main sections and presented in two volumes:

Volume One

Section 1 - Introduction

Section 2 - Description of the Project Area

Section 3 - Description of the Proposed Action

Volume Two

Section 4 - Planned Environmental Protection Procedures

Section 5 - Environmental Effects of the Proposed Action
After Mitigation

Section 6 - Monitoring Program

Section 7 - Alternatives and Selection Rationale

Each of the seven sections is described briefly below:

- Introduction. Section 1 presents a general outline of the DDP, discusses issuance of the leases for Tracts Ua and Ub, describes the White River Shale Project, and briefly recounts exploration and baseline data collection.
- Description of the Project Area. Section 2 is a condensation of the Final Environmental Baseline Report (Ref. 1-2), a 24-month environmental survey and analysis prepared for WRSP by VTN, and continuing studies by VTN, AeroVironment, BioResources, and Utah State University, the results of which have been published in annual progress reports.
- Description of the Proposed Action. Section 3 describes the most probable plan for the project from its inception through all of its development and operation activities to the conclusion of decommissioning or abandonment.
- Planned Environmental Protection Procedures. Section 4 describes the procedures proposed for mitigation of adverse environmental effects incurred by implementation of the most probable plan.
- Environmental Effects of the Proposed Action After Mitigation. Section 5 explains the net environmental effects that may be expected by implementing the most probable plan described in Section 3 and the protection procedures described in Section 4.

- Monitoring Program. Section 6 describes the required environmental monitoring program that is, in part, an extension of the baseline monitoring program. Other effects that will occur during the program will be monitored to ascertain that controls are adequate.
- Alternatives and Selection Rationale. Section 7 describes various alternatives to the plan in Section 3 and outlines the reasons for choosing the most probable plan.

A glossary and list of abbreviations are also included in both volumes.

1.2 THE OIL SHALE PROTOTYPE PROGRAM

In June 1971, the Secretary of the Interior announced plans for an oil shale development program. At that time, he released a preliminary environmental statement (Ref. 1-3), a program statement (Ref. 1-4), and reports prepared by the states of Colorado, Utah (Ref. 1-5), and Wyoming on environmental costs and problems of oil shale development. These actions followed President Nixon's energy message in which he asked the Secretary of the Interior to initiate a "leasing program to develop our vast oil shale resources, provided that environmental questions can be satisfactorily resolved."

The resulting prototype program is designed to develop U.S. oil shale resources by the following plan of action:

- Develop mining and retorting technology for oil shale production
- Stimulate private industry to produce commercial quantities of oil from shale
- Ensure that the environmental integrity of the area is maintained to the greatest degree possible
- Develop methods and technology for protection of the environment
- Permit an equitable economic return for all parties
- Develop leasing management expertise for oil shale production

The Department of the Interior requested nominations in November 1971 of proposed tracts for lease, and 20 individual tracts of oil shale land were nominated. In April 1972, with the concurrence of the states concerned, the Department announced the selection of six of these tracts: two each in Colorado, Utah, and Wyoming.

The program is essentially unchanged from the one announced in June 1971, but the preliminary statement issued at that time was expanded to consider the impact of mature oil shale development, to examine the impact of developing the six specific tracts, and to include a comprehensive analysis of energy alternatives.

The draft of the Final Environmental Statement was released by the Department of the Interior to the public in September 1972. Subsequent public review, ending in November 1972, provided important information for expanding and correcting the draft material, where appropriate. The Final Environmental Statement for the Prototype Oil Shale Leasing Program was issued in August of 1973 (Ref. 1-6). That document is based on information from many sources, including research data and pilot programs developed by both the government and private industry over the past 30 years. Many factors -- such as changing technology, eventual oil production levels, and attendant regional population increases -- are not precisely predictable. However, the impact analysis is regarded as a reasonable treatment of the potential regional and specific environmental effects associated with oil shale development.

To assist and advise the Department of the Interior about environmental matters connected with the operation of oil shale leases, an Oil Shale Environmental Advisory Panel (OSEAP) was established by the Secretary of the Interior in accordance with the provisions of the Federal Advisory Committee Act, Public Law 92-463 (Ref. 1-7). The OSEAP is composed of members appointed from bureaus within the Department and from other interested federal agencies, of members representing state and local governments, and of members of the general public active in environmental matters. The function of the panel is to advise promptly the District Manager of the Bureau of Land Management, the Mining Supervisor of the Geological Survey (Area Oil Shale Supervisor), and any other officers or employees of the department about environmental matters involving their respective responsibilities under the prototype oil shale leasing program.

1.3 LEASE ISSUANCE AND STATUS

The six tracts selected in Colorado, Utah, and Wyoming for the Federal Oil Shale Leasing Program all involve the rich Green River Formation; oil yield from this mineable zone may average 30 gallons per ton of shale. Competitive bidding on the six tracts took place from January to June 1974, and bids were received and accepted on both tracts in Utah and in Colorado. No bids were made on the Wyoming lands.

Both of the Utah leases (Ref. 1-1) went into effect June 1, 1974 (Tract Ua: Department of Interior, Bureau of Land Management Oil Shale Lease Number U-25918; and Tract Ub: Department of Interior, Bureau of Land Management Oil Shale Lease Number U-26194). Tract Ua was leased by Phillips Petroleum Company and Sun Oil Company (Delaware). Tract Ub was originally leased by the White River Shale Oil Corporation, comprising Phillips Petroleum Company, Sun Oil Company (Delaware), and Sohio Petroleum Company. (Sun Delaware's interest was later fully assigned to Sunoco Energy Development Company.) Tract Ub has since been fully assigned to Sohio Petroleum Company, now Sohio Shale Oil Company.

The terms of both leases were suspended effective November 1, 1976 because of several environmental questions that had to be resolved before the leased properties could be developed. The suspension was for a term of one year.

Before the suspension expired, the owners of the leases to Tracts Ua and Ub were granted a preliminary injunction against the Department of the Interior that indefinitely suspended the terms, conditions, and obligations of the leases. The injunction ruling was based on the existence of conflicting claims on the title to Tracts Ua and Ub. This injunction is still in effect, but progress is being made toward resolving the questions. The injunction will be lifted prior to approval of the DDP.

1.4 THE WHITE RIVER SHALE PROJECT

At the present time, the detailed development plan contained in this document is regarded as the most probable among many alternatives for the development of oil shale resources on federal lease Tracts Ua and Ub in northeastern Utah. This plan calls for staged development of mining, processing, and related operations in three phases.

Phase I of the most probable plan comprises mining and retorting designed to generate specific information on ore body characteristics that cannot be determined by core drilling, and information on the retorting process itself. This operation, in which up to 30,000 tons per day of shale will be mined, will permit selection of those engineering designs best suited to producing oil from the specific shale mined from Tracts Ua and Ub on a larger scale and in a manner that is environmentally sound and economically viable. Phase I oil production will be 14,930 barrels per stream day.

Phases II and III of the most probable plan cover the growth of shale oil production to a level of 50,000 to 100,000 barrels per day, respectively, continuing through operation to the exhaustion of the oil shale resources of the lease tracts. Included in all phases are the support facilities needed at each stage of development, including facilities to supply water, power, and access requirements.

The plan outlined in this document is intended only to represent conditions at the time that decisions need to be made regarding proceeding with the project. Nothing in this plan should be construed to mean that alternative courses could not be pursued, with the approval of the AOSS.

1.4.1 PROJECT ORGANIZATION

The White River Shale Project contemplates joint development of federal lease Tracts Ua and Ub, and this DDP has been prepared on that basis. A unitization application has been filed by WRSP and is pending in Washington, D.C. with the Department of the Interior.

Tract Ua is leased by:

- Phillips Petroleum Company
324 Frank Phillips Building
Bartlesville, Oklahoma 74004
- Sunoco Energy Development Company
12700 Park Central Place
Dallas, Texas 75251

Tract Ub is leased by:

- Sohio Shale Oil Company
1100 Beneficial Life Tower
36 South State
Salt Lake City, Utah 84111

1.4.2 TRACTS Ua AND Ub

Maps and more detailed descriptions of Tracts Ua and Ub are found in Section 2 of this DDP and in the supporting document, Final Environmental Baseline Report (Ref. 1-2), and project annual reports (Ref. 1-8).

1.4.2.1 Location and Description

Tracts Ua and Ub lie immediately south of the White River in the eastern part of the Uinta Basin in a remote part of northeastern Utah. Tract Ua lease is in the county of Uintah, Utah and contains 5,120,000 acres, more or less. It includes:

T. 10 S., R. 24 E., SLM, Utah
Sec. 19, E $\frac{1}{2}$
Sec. 20, All
Sec. 21, All
Sec. 22, All
Sec. 27, All
Sec. 28, All
Sec. 29, All
Sec. 30, E $\frac{1}{2}$
Sec. 33, N $\frac{1}{2}$
Sec. 34, N $\frac{1}{2}$

Tract Ub lease is in the county of Uintah, Utah and contains 5,120.00 acres, more or less. It includes:

T. 10 S., R. 24 E., SLM, Utah
Sec. 12, S $\frac{1}{2}$, S $\frac{1}{2}$ N $\frac{1}{2}$
Sec. 13, All
Sec. 14, All
Sec. 23, All
Sec. 24, All
Sec. 25, W $\frac{1}{2}$ W $\frac{1}{2}$
Sec. 26, All

T. 10 S., R. 25 E., SLM, Utah
Sec. 18, All
Sec. 19, All

A map showing the location of the two tracts is presented in Figure 1.4-1. The nearest community is Bonanza, about 10 miles away, with a population of approximately 20; the nearest town in Utah having a full range of services is Vernal, population approximately 8,000; and the nearest town in western Colorado is Rangely, about 30 miles away. Vernal is served by U.S. Route 40 and Bonanza by Utah Route 45. From Bonanza, the tracts and the proposed process areas can be reached by dirt roads that are not a part of the state system.

The only major perennial stream in the area is the White River, whose valley occupies a narrow strip about 800 feet wide at the northern edge of Tracts Ua and Ub. Southam Canyon, a slightly meandering drainage, extends northward across Tract Ua and joins the White River just outside the tract. The canyon of Evacuation Creek trends northward across the central part of Tract Ub. West of Evacuation Creek, the terrain is more rugged and is characterized by ledges and cliffs along the canyon walls and numerous buttes along the drainage divides. Ground cover in both tracts is sparse, consisting mostly of shrubs. Surface elevations within the tracts range from 4,900 feet at the White River to approximately 5,960 feet in the south-central part of Tract Ua. The greatest altitude difference in a short distance is about 450 feet in 1/2 mile in the south-central part of Tract Ua.

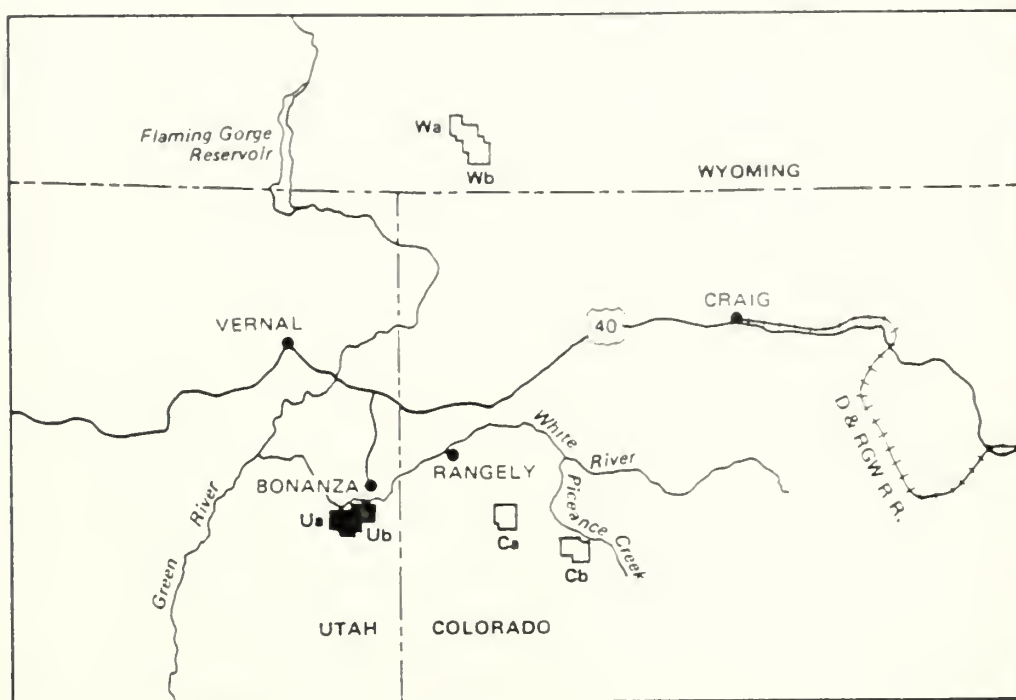


Figure 1.4-1 LOCATION OF TRACTS Ua AND Ub

1.4.2.2 Geology

The Uinta Basin is a sedimentary, structural, and topographic basin. Oil shale of the Green River Formation is exposed along the south and east margins of the basin, and is concealed by younger sediments in the central and northern parts of the basin. Available drilling information indicates that the thickest, richest oil shale is in the eastern half of the basin, mostly concealed by younger rocks of the Uinta Formation. Geologic maps and a description of the oil shale in the southeastern part of the Uinta Basin are contained in Reference 1-9.

The Green River Formation conformably underlies the Uinta Formation and is composed of the Parachute Creek, Garden Gulch, and Douglas Creek Members. The Parachute Creek Member is of major interest because it contains the rich oil shale sequence known as the Mahogany Zone.

The Parachute Creek Member consists of finely laminated siltstones, marlstones, and oil shales with numerous thin tuff beds, deposited in a deep-water lacustrine environment. Oil shale is commonly defined as kerogen-rich marlstone that yields more than 15 gallons of oil per ton. Within the Parachute Creek Member, the 100-foot-thick Mahogany Zone occurs approximately 500 feet below the top of the member (Ref. 1-3). Approximately 40 feet below the top of the Mahogany Zone, the 10-foot-thick Mahogany bed occurs; it is the richest bed of oil shale. Part of the Mahogany Zone, including the Mahogany bed, is the prime target for underground mining.

1.4.2.3 Mineral Resources

Tract Ua. Samples from Tract Ua show an average thickness of approximately 55 feet for oil shale with an average Fischer assay yield of 28 gallons of shale oil per ton. Overburden above the Mahogany Zone ranges from 550 to 1,225 feet; the average is approximately 850 feet. The shale oil resource present in the mining zone is estimated to be 540 million barrels (Ref. 1-6). Current estimates indicate that approximately 70 percent of these reserves can be recovered by underground mining methods. Nahcolite is present in the tract only as very thin lenses and small pods. No significant amounts of bituminous sandstone are reported in Tract Ua.

Four deep gas wells were previously drilled on the tract. Three were abandoned, and one remains capped. This shut-in well flowed at 11,000 cubic feet per day from a zone 3,300 feet below surface. A commercial gas reserve is not anticipated under Tracts Ua and Ub.

Tract Ub. Assayed samples from core holes in Tract Ub also show that the rich zone of shale averages 55 feet in thickness. Overburden above the principal oil shale beds ranges from 300 to 1,250 feet, and the average is

about 700 feet. The shale oil resource in the mining zone on the tract is estimated to be about 510 million barrels (Ref. 1-6), approximately 70 percent of which should be recoverable by underground mining. Nahcolite occurs as very thin lenses or beds and small pods in the upper part of the Green River Formation. No commercial oil or gas has been discovered on this tract, and no significant amount of bitumen is known to occur in the sandstone. There is one narrow Gilsonite vein, less than 2 inches wide, in the west-central part of the tract (Ref. 1-9).

Off Tract. Off tract, a group of about 14 productive gas wells have been completed and are located approximately 4 to 5 miles southwest of Tract Ua. Another three productive gas wells are located 1.5 to 3 miles northwest of Tract Ua. Although these wells penetrate the entire thickness of the Eocene strata, the principal productive zone, the Mesa Verde Formation of Cretaceous age, lies considerably deeper in the section.

1.4.2.4 Water Resources

Tracts Ua and Ub are close to the White River, which could supply water for the project. The mean flow of the White River in this reach is approximately 700 cubic feet per second, and the weighted average-dissolved-solids concentration is approximately 400 to 500 milligrams per liter. Water could also be obtained from the Green River and from the Flaming Gorge Reservoir by diverting and pumping at a point on the Green River about 30 miles from the tracts.

Groundwater occurs in the Bird's Nest Aquifer above the oil shale, and in the Douglas Creek Aquifer below the mine zone, but data indicate that the yields are generally small. The groundwater supply does not appear to be large enough to provide a significant supply of water for operations at Tracts Ua and Ub.

1.4.2.5 Climate and Air Resources

The climate of both Tracts Ua and Ub is semiarid. Annual precipitation ranges from approximately 8 inches at lower elevations to 11 inches over higher terrain, with about 4 inches from May to September, mostly from thunderstorms, and 6 inches from October to April. Approximately 30 to 40 days per year have more than 0.01 inch of precipitation. Severe local thunderstorms in summer may cause strong, gusty winds and local flash flooding.

The average annual snow accumulation is about 10 inches, but open areas may remain free of snow for most of the winter.

The area has dry hot summers, with a 5-year average July maximum temperature of 95F, an extreme of 97F, and an average July mean of 75F. The winters are relatively dry and cold. The 5-year average minimum for January is -10F, the extreme minimum recorded is -22F, and the average January mean is 15F. The frost-free period is approximately 144 days.

Surface airflow on the tracts is complicated by rough terrain effects. During the early morning hours, the air generally flows along drainage channels toward low terrain and along the White River. In the afternoon, winds are stronger and less variable, flowing generally from the west or southwest. Air quality on the tracts, with few exceptions, has consistently been very good, as is expected for a remote location.

1.4.2.6 Biological Resources

The biotic communities on and near the tracts are of the cold desert shrub type. The vegetation is, for the most part, shrub-dominated. High soil salinity and a preponderance of salt-tolerant shrubs are characteristic of the area. Poplar trees dominate the riparian areas, and Juniper trees predominate in the higher elevations at the southern edge of the tracts.

Sheep graze on the tracts in winter and early spring, and some cattle graze in riparian areas in spring and summer. The greatest impact on the area comes from sheep being driven across the eastern portion of Tract U_b.

From late summer to early winter, mule deer can be found along the White River riparian habitat and adjacent areas. The tract area is occasionally used for hunting. The only small-game species on the tracts is the cotton-tail rabbit. Eighteen species of rodents and six species of carnivores have been observed; porcupines are found in riparian habitats, and coyotes, racoons, skunks, bobcats, and badgers are found throughout the tracts.

The tracts support a breeding population of mourning doves, and there are small breeding populations of Canada geese, mallard ducks, and green-winged teal along the White River. Other species of game bird are uncommon or occur as spring transients. Seventeen species of raptors have been observed on or near the tracts, and 114 bird species other than game birds and raptors have been observed.

Reptiles occur in all four vegetation types in the White River region. Six species of lizards and five species of snakes have been observed on the tracts. Four amphibian species were found on the tracts in the riparian vegetation along the White River and Asphalt Wash.

Approximately 1,500 species of insects have been collected on or near the tracts.

1.4.2.7 Historical Resources

The Uinta Basin was primarily the homeland of the Ute Indians. The first European contacts were with Spanish explorers and traders from the south. The first year-round white settlement was a trading post established at Fort Rubidoux in 1838. The colonization of the area by Mormon settlers in the latter decades of the 19th century greatly influenced the shaping

of the present economy and culture of the Uinta Basin. Although the Wasatch Front was settled earlier, the first Mormons did not enter and explore the Uinta Basin until 1861. The agrarian settlers and the Ute inhabitants were in direct competition for the limited resources available, and an extended period of recurring hostilities ended with the transfer of Utes to the Uinta and Uncompahgre Reservations in 1881.

Another important influence on the evolution of the Uinta Basin was the discovery and extraction of the area's rich mineral resources, particularly the discovery of Gilsonite in the late 1800s. Gilsonite mining grew rapidly and hastened the development of the area.

The most important historic feature on or near Tracts Ua and Ub is the Ignatio Stage Station on the White River, north of Tract Ub. This site, one of a series of stage stops along the Uintah Railway toll road that connected the rail line to Vernal, has been nominated for inclusion in the National Register of Historic Sites; if registered, it will be protected by special regulations and will be eligible for federal funding for preservation or restoration purposes. The remaining structures at the site are good examples of late frontier architecture in this part of the country, but are in poor condition.

1.4.3 PROJECT DEVELOPMENT

A project schedule for the White River Shale Project (WRSP) is presented in Figure 1.4-2, and a brief description of the project follows. A more detailed description of the items shown on the schedule is found in Section 3.

1.4.3.1 Preliminary Planning

Early planning was contained in a Preliminary Development Plan (Ref. 1-10) submitted in April 1974 in accordance with the Department of Interior's prototype oil shale leasing program and with instructions published by the Department of Interior in the Federal Register of November 30, 1973 (Ref. 1-11). It is important to note that this early plan was a preliminary plan

to be modified as additional data and information became available. At that time, the lessee intended to discuss in a general way the development of Tracts Ua and Ub, realizing that a great deal of additional information was needed to prepare the present plans, which are discussed in this Detailed Development Plan.

1.4.3.2 Exploratory and Baseline Activities

Exploration, coring, and environmental baseline activities were initiated on the tract and plant site area in the summer and fall of 1974. The primary objective of these activities was to develop and install various monitoring stations for baseline data collection. Test wells were drilled and surveyed, and air and water monitoring stations were placed in operation before the winter season (1974-75). The preliminary activity on the tract was governed by the lease and CFR Title 43 Part 23, and Title 30 (Ref. 1-12) concerning surface exploration, mining, and reclamation of public lands.

Environmental monitoring activities were continued after completion of the 2-year environmental baseline monitoring program in January 1977. Additional new data have been collected, previous findings investigated, techniques refined, and the baseline data base extended.

1.4.3.3 Initial Mine Access and Phase I Retort Operation

The WRSP will start sinking three mine shafts and developing a room-and-pillar mining operation to supply feed for two vertical surface retorts suitable for processing shale and producing 14,930 barrels of oil per stream day. The objectives of Phase I are as follows:

- To initiate a significant level of mining activity on Tracts Ua and Ub in order to establish rock mechanics, gas content, retorting and crushing characteristics, and other operational characteristics of the shale rock
- To prove commercial-sized surface retorting through operating two large-scale units, and to provide a basis for selecting a retort technology for use in Phases II and III

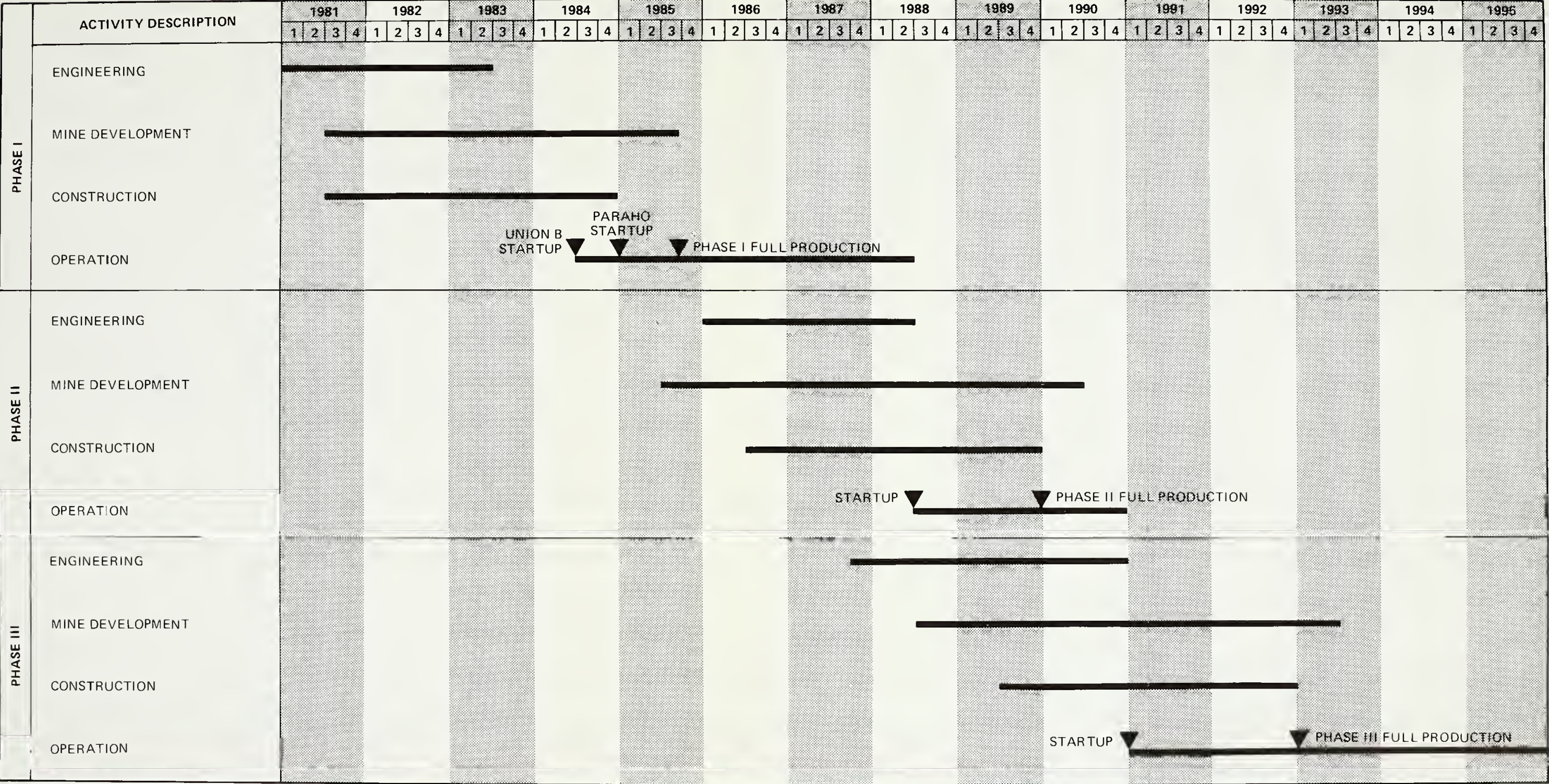


Figure 1.4-2 WHITE RIVER SHALE PROJECT SCHEDULE

- To ascertain production costs at near-commercial scale in order to define the economics of producing shale oil
- To determine accurately the environmental effects of operating the commercial demonstration facilities, and the means of mitigating and controlling adverse effects
- To begin operations with an orderly development of facilities, personnel, and actions designed to fit into and become part of the future phases as far as practicable

1.4.3.4 Facilities Engineering and Construction

Successful initiation and operation of the Phase I retort installation will be followed by engineering and construction of two further phases. The resulting total output capacity will be nominally 50,000 BPD after Phase II, and 100,000 BPD after Phase III.

1.4.3.5 Production and Processing

The most probable scheme for commercial shale oil production and processing comprises mining and aboveground retorting. For the purposes of planning in this report, the Phase III commercial shale oil facility has been sized at 100,000 BPD.

In Phase III, mining operations will produce about 178,500 TPD of raw shale. The mine will employ proven room-and-pillar techniques, modified as necessary on the basis of the experience gained during Phase I. Mining will recover approximately 65 percent of the in-place ore. The raw shale will be prepared as retort feed by several stages of crushing and screening, with primary crushing carried out in the mine. The coarse-crushed raw shale will be lifted to the surface, where it will undergo secondary crushing and be reduced to an appropriate size for retorting. A stockpile of primary-crushed raw shale will be maintained to ensure steady operations.

The bulk of the raw shale from secondary crushing will be processed in vertical direct-heated and indirect-heated retorts to achieve the gas quantity

and composition required by subsequent operations and by the process heat balance. The remainder of the crushed raw shale will be stockpiled in Phase I, and will be processed in fines-type retorts.

The crushed raw shale will be fed to the retorts by covered conveyors, which will also transport the processed shale to Southam Canyon for disposal. In Southam Canyon, the processed shale will be placed in accordance with a program designed to permit handling of these very large quantities of material in a manner that is structurally, environmentally, and economically sound.

Supporting facilities will consist of gas treating for sulfur recovery, wastewater treating, sour water stripping, product storage, product movement, relief and blowdown systems, utilities, water supply, wastewater treatment, solid waste handling, and maintenance and administrative facilities. Sulfur produced from the facility will amount to approximately 140 TPD and will be stockpiled for possible future recovery. Ammonia will be burned in reducing burners.

The shale oils from the facility will have the approximate properties shown in Table 1.4-1.

Table 1.4-1
PROPERTIES OF RAW SHALE OIL

Property	Direct Heat Retort	Indirect Heat Retort	Fines Retort
Product Quantity, BPSD	89,040	7,910	1,320
Pour Point, F	85	60	80
Gravity, °API	21	20.8	22.0
Viscosity, CS @ 100F/210F	22/6.3	20/3.7	22/3.8
Sulfur Content, wt %	0.6	0.8	0.7
Nitrogen Content, wt %	1.4	1.8	1.9

1.4.3.6 Support Facilities

Electric power will be purchased from Moon Lake Electric Association, Inc. during Phase I construction, Phase I operation, and Phase II construction. Moon Lake operates a power line near Tracts Ua and Ub that is adequate to supply the quantities of power required during these early periods. For the construction of Phase III and the operation of Phases II and III, electric power will be provided from onsite generating sources. Moon Lake will provide startup and standby power for all phases. Power lines to carry the plant load will be provided.

During Phase I, water will be purchased from a supply available from a dam on the White River proposed for construction by the state of Utah; a pump station about 500 feet from the water's edge will raise the required quantity of water from river level to the project site as needed. If the reservoir is not available when water is needed, the water will be drawn from shallow alluvial wells located at the river bank and pumped to the plant site.

Raw shale oil, and any other by-products generated, will be transported by truck during Phase I. The quantity of oil produced (up to 14,930 BPSD) is suitable for movement by truck. During Phases II and III, the oil will be transported by pipeline. In the most probable plan, the oil will be moved by pipeline to an existing refinery in Borger, Texas.

1.5 EXPLORATION AND BASELINE DATA COLLECTION

1.5.1 EXPLORATION PROGRAM

The Partial Exploration Plan submitted by Sun Oil Company and Phillips Petroleum Company for Tract Ua and by the White River Shale Oil Corporation for Tract Ub covered the exploratory drilling program following award of the leases (Ref. 1-10). The lessees drilled 14 core holes on Tracts Ua and Ub to supplement the initial seven holes drilled as part of the tract nomination program, plus the four pilot test holes for the groundwater hydrology program.

The core drilling program provided for an approximate 1-mile spacing of holes for this phase of the program. Additional core hole locations will be proposed for approval if further geologic and structural information is required for mine design or operation.

The objectives of the proposed program were to:

- Determine oil shale grade throughout the tracts
- Determine whether major fault offsets occur in the oil shale mining zone
- Determine the principal partings, joints, and fracture systems in the oil shale mining zone and their continuity within the tracts
- Determine horizontal and vertical position of the strata
- Provide core samples for strength-of-materials testing for initial mine planning and design
- Provide additional subsurface hydrologic data

Twenty-three vertical core holes, including the four pilot test holes, have been drilled on the two tracts. An additional two holes were drilled at an incline to determine the existence of vertical joints and fractures.

Drill cuttings were collected at 10-foot intervals except for cored intervals. Oil yield assays were run on 1-foot increments of the cores using the modified Fischer assay retort method. Analyses for nahcolite were run where this mineral was identified in the cores. No Dawsonite was identified in the cores. Other mineralogical and trace element analyses were run on the raw and processed shale samples as required. Portions of the recovered cores were also used for physical testing. The Fischer-assay-processed shale from 13 of the core tests was assayed for extractable alumina. In none of these core tests did alumina average as much as 0.5 percent over the proposed mining interval.

The rock mechanics evaluation of the physical characteristics of the ground mass immediately above and below the economic oil shale zone, and also within the zone, will provide design criteria for underground mine development. Test specimens were taken from the core at 10-foot intervals, starting 50 feet above the ore zone and continuing to 50 feet below the ore zone. At each test interval, sufficient core samples were taken to allow for the preparation of two test specimens: one was tested to destruction and one was preserved for further testing at a future date.

1.5.2 BASELINE DATA COLLECTION

An environmental baseline survey was begun in the fall of 1974 in accordance with lease stipulations, and was completed in January 1977. Data collection programs are continuing, and are based on the results and findings of the baseline program. Data were compiled in the areas of water resources, air resources, biological resources (terrestrial and aquatic), geology, historic resources, and aesthetics. This program, along with continuing monitoring studies was conducted in accordance with the Partial Exploration Plan, Environmental Baseline Data Collection and Monitoring Element (Ref. 1-13) submitted July 1, 1974, and the conditions of approval developed by the AOSS for various subelements of the program. The results of the baseline data collection program were the subject of the Final Environmental Baseline Report published in October 1977 (Ref. 1-2).

1.6 SUMMARY OF COSTS

Table 1.6-1 summarizes the expected costs of the three phases of the White River Shale Project.

Table 1.6-1

ESTIMATED CAPITAL AND OPERATING COSTS^(a,b)

Phase	Incremental Capital Costs (Million \$)	Incremental Operating Costs (Million \$/yr)	Total Shale Oil Produced (BPSD ^(c))
Phase I	564.1	52.9	14,930
Phase II	1,268.7	98.0	58,740
Phase III	1,200.9	113.1	109,770
Total	3,032.7	264.0	-

(a) All costs are within an accuracy of 25 percent.

(b) Estimates are based on conceptual design of the "Most Probable Plan" as described in the Detailed Development Plan. Capital costs include owner's costs subsequent to 1980.

(c) 328.5 days per year.

REFERENCES — SECTION 1

- 1-1 Federal Oil Shale Leases, Nos. 25918 and 26194, June 1, 1974.
- 1-2 Final Environmental Baseline Report, White River Shale Project, VTN, Denver, Colorado, October 1977.
- 1-3 Preliminary Environmental Statement, U.S. Department of Interior, Washington, D.C., June 1971.
- 1-4 Draft Environmental Impact Statement for the Proposed Prototype Oil Shale Leasing Program, Volume III, U.S. Department of the Interior, Washington, D.C., September 1972.
- 1-5 Prospects for Oil Shale Development: Colorado, Utah, and Wyoming, U.S. Department of the Interior, Washington, D.C., May 1968.
- 1-6 Final Environmental Statement for the Prototype Oil Shale Leasing Program, U.S. Department of the Interior, Washington, D.C., 1973.
- 1-7 Federal Advisory Committee Act, Public Law 92-463, as published in the Federal Register, Vol. 39, No. 45, March 6, 1974.
- 1-8 Progress Report, Environmental Program, 1977, WRSP, Vernal, Utah, July 1978.

and

Progress Report, Environmental Program, 1978, WRSP, Vernal, Utah, July 1979.

and

Progress Report, Environmental Program, 1979, WRSP, Vernal, Utah, September 1980.

- 1-9 W. B. Cashion, "Geology and Fuel Resources of the Green River Formation, Southern Uinta Basin, Utah, and Colorado," Professional Paper 548, U.S. Department of the Interior, Geological Survey, Washington, D.C., 1967.
- 1-10 Prototype Oil Shale Leasing Program, Utah Tract Ua, Preliminary Development Plan, submitted by Phillips Petroleum Company and Sun Oil Company, Delaware, March 1974.

and

Prototype Oil Shale Leasing Program, Utah Tract Ub, Preliminary Development Plan, submitted by the White River Shale Oil Corporation, April 1974.

- 1-11 Federal Register, Vol. 38, No. 230, Part III, U.S. Department of the Interior, Washington, D.C., November 30, 1973.

- 1-12 Federal Register, Code of Federal Regulations, Title 43, Part 23,
and Title 30, Vol. 23, No. 852, Washington, D.C., January 18, 1969.
- 1-13 Partial Exploration Plan, Environmental Baseline Data Collection
and Monitoring Element, Sun Oil Company, Phillips Petroleum Company,
and White River Shale Oil Corporation, July 1974.

Section 2

DESCRIPTION OF PROJECT AREA

2.1 INTRODUCTION

Section 2 briefly describes the project area and highlights the resources of the region. Subjects covered include:

- Geology and soils
- Water resources
- Air resources
- Biological resources
- Historic, prehistoric, and paleontological resources
- Aesthetics

In Section 5, "Environmental Effects of the Proposed Action," these subjects are examined to determine the net positive or negative effects of project construction and operation described in Section 3, after implementation of the planned environmental protection procedures discussed in Section 4.

This presentation of the setting, both on and around Tracts Ua and Ub, is based on the Final Environmental Baseline Report (Ref. 2-1) and on subsequent field studies. Because the intent of this part of the DDP is to offer a succinct narrative description of the general trends observed, the discussion is necessarily brief. Those who are interested in a more detailed technical discussion of the various topics presented, or who are concerned with the statistical validity of the data, are directed to the corresponding section of the baseline report and to subsequent annual reports. The field study and data processing techniques used for the baseline programs are described in detail in the Partial Exploration Plan (Ref. 2-2), and in annual reports.

2.2 GEOLOGY AND SOILS

2.2.1 PHYSIOGRAPHY

Tracts Ua and Ub are located in the eastern part of the Uinta Basin, a broad, asymmetric basin located on the northeastern edge of the Colorado Plateau (Figure 2.2-1). Lacustrine sediments of a prehistoric lake basin dominate the stratigraphy of the Uinta Basin. Major land features bordering the basin are the Uinta Mountains on the north, the Wasatch Range on the west, the Roan Cliffs on the south, and the highlands associated with the subsurface Douglas Creek Arch along the eastern edge.

Tracts Ua and Ub are bounded by the White River to the north, Hells Hole Canyon to the east, upland areas of elevations between 6,000 and 6,200 feet to the south, and Asphalt Wash to the west. The region near the tracts, including all the area extending southward to the Roan Cliffs and westward to the Green River, is a gently northsloping, highly dissected plateau, characterized by steep-walled canyons with ephemeral streams or dry washes that are subject to occasional flash floods. The relief of these canyons averages 30 to 50 feet, but in some places is as much as 1,000 feet.

2.2.1.1 Geomorphology

In the southeastern portion of the Uinta Basin, intertributary divides between major drainages are broad and capped by resistant rock strata. These strata dip northwestward a little more steeply than does the plateau surface itself to create narrow, benchlike mesas, cuestras, and hogbacks. Within Tracts Ua and Ub, the landscape is composed of a series of north- and south-trending valleys separated by narrow, elongated mesas. There are three dominant ridge sections that trend just west of north, north, and just east of north as one proceeds from east to west across the tracts. The general direction of these landforms is perpendicular to that of the White River.

2.2 GEOLOGY AND SOILS

2.2.1 PHYSIOGRAPHY

Tracts Ua and Ub are located in the eastern part of the Uinta Basin, a broad, asymmetric basin located on the northeastern edge of the Colorado Plateau (Figure 2.2-1). Lacustrine sediments of a prehistoric lake basin dominate the stratigraphy of the Uinta Basin. Major land features bordering the basin are the Uinta Mountains on the north, the Wasatch Range on the west, the Roan Cliffs on the south, and the highlands associated with the subsurface Douglas Creek Arch along the eastern edge.

Tracts Ua and Ub are bounded by the White River to the north, Hells Hole Canyon to the east, upland areas of elevations between 6,000 and 6,200 feet to the south, and Asphalt Wash to the west. The region near the tracts, including all the area extending southward to the Roan Cliffs and westward to the Green River, is a gently northsloping, highly dissected plateau, characterized by steep-walled canyons with ephemeral streams or dry washes that are subject to occasional flash floods. The relief of these canyons averages 30 to 50 feet, but in some places is as much as 1,000 feet.

2.2.1.1 Geomorphology

In the southeastern portion of the Uinta Basin, intertributary divides between major drainages are broad and capped by resistant rock strata. These strata dip northwestward a little more steeply than does the plateau surface itself to create narrow, benchlike mesas, cuestas, and hogbacks. Within Tracts Ua and Ub, the landscape is composed of a series of north- and south-trending valleys separated by narrow, elongated mesas. There are three dominant ridge sections that trend just west of north, north, and just east of north as one proceeds from east to west across the tracts. The general direction of these landforms is perpendicular to that of the White River.



Figure 2.2-1 PHYSIOGRAPHIC MAP OF THE UINTA BASIN REGION

Physical weathering processes on Tracts Ua and Ub include frost action and mass wasting. Chemical weathering by solution, oxidation, and carbonation is also an important phenomenon. Sheet wash leads to colluvium deposits on slopes and the piling of debris upgradient from vegetation established on slopes. Gully erosion is also prevalent. Large amounts of sediment are picked up by water flowing down Asphalt Wash, Southam Canyon, and Evacuation Creek during occasional high-intensity summer thunderstorms. Erosion of dirt roads that parallel or traverse sections of these channels and their tributaries further contributes to the sediment load.

There is a greater diversity of ground slope gradients on Tract Ua than on Tract Ub, and the slopes found within Tract Ub (Figure 2.2-2) are more gentle. The steepest slopes on the tracts are found adjacent to Evacuation Creek as it flows through Tract Ub, along the northwest-trending ridge that lies in the west portion of Tract Ua, within the southeast corner of Tract Ua, and in the southwest portion of Tract Ub. Channel cutting along the White River has also created steep slopes near the north borders of both tracts. The most gentle slopes occur on the mesa tops that lie parallel to and along Evacuation Creek, in northern portions of Tract Ub, and in sections of the eastern portions of Tract Ub. Level to gently sloping land is found in the south and southwest portions of Tract Ua.

Geologic structure and erosion have influenced the development of several landforms on the tracts, especially rock pinnacles and balanced rocks. These numerous and prominent forms occur on or near ridgetops. They have been developed by progressive headward erosion from drainages along vertical fractures or joints. Over long periods, this process leaves large isolated blocks of rock standing, whose development is enhanced by the presence of a more resistant caprock. In addition, large rock faces on canyon walls along the White River plainly show evidence of massive rock failures. These rock failures have occurred along vertical fractures that are generally perpendicular to the bedding.

2.2.1.2 Drainage Basin Form and Process

The overall drainage pattern of the Uinta Basin is predominantly dendritic, but because of the influence of the northwest-trending and northeast-trending sets of joints in the surficial rock formations, there are many straight reaches along stream channels. Larger streams of the basin have well developed, meandering channels within their relatively straight, steep-walled flood channels. Level portions of land near the river exhibit a fine-textured drainage density, while upland areas of the Uinta Formation remain relatively undissected. Surficial outcrops of the Parachute Creek Member of the Green River Formation have a higher drainage density than the Uinta Formation.

2.2.2 GEOLOGIC HISTORY

In its early stages of formation, during the Paleocene Epoch, the Uinta Basin was the northeastern portion of a much larger intermontane lake basin that spread over most of Utah. Beginning with the Early Eocene Epoch, Lake Uinta covered the entire Uinta and Piceance Creek Basins and possibly connected with another large lake that covered most of southwestern Wyoming. By the close of middle Eocene time, this lake basin had dried up after accumulating a thick sequence of deep sediments from the surrounding highlands to form the present figuration of the Uinta Basin.

Sequences of strata that crop out in this region reflect the different stages of evolution of the basin. When Lake Uinta existed in its maximum dimensions, the Green River Formation sediments and organic matter accumulated on the lake bottom. As the lake diminished because of further rise of the Uinta Mountains and the Douglas Creek Arch, alluvial sediments of the Uinta Formation were deposited over the surface of the Uinta Basin by meandering streams (Ref. 2-3).

2.2.3 STRATIGRAPHY

2.2.3.1 Green River Formation

The Green River Formation is an Eocene Series that consists primarily of light-gray to dark-gray, hard, brittle marlstone and oil shale, interbedded

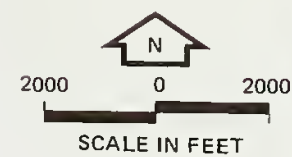
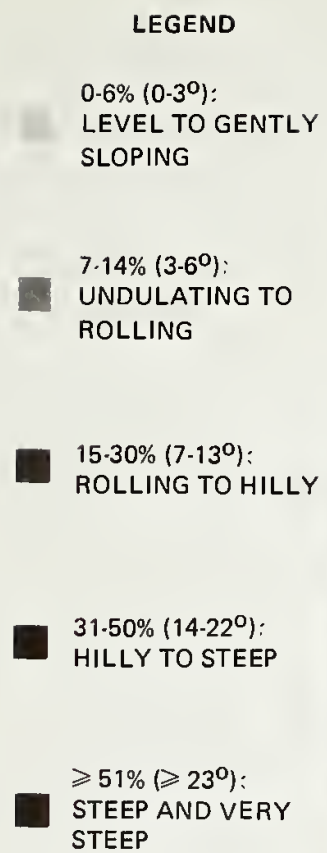


Figure 2.2-2 SLOPE GRADIENT MAP—
TRACTS Ua AND Ub

with relatively minor amounts of brown sandstone, siltstone, nahcolite nodules, and thin volcanic tuff beds. Total thickness of the formation beneath the tracts is about 1,600 feet. The uppermost portion of the Green River Formation is exposed along Evacuation Creek and in the far northeastern edge of Tract Ub (Figure 2.2-3). Bradley (Ref. 2-4) described in detail the origin and occurrence of the Green River Formation. More recent work (Ref. 2-5) has led to a revised subdivision and nomenclature for the members of the Green River Formation. These members are listed and described in ascending stratigraphic order in the following paragraphs.

Douglas Creek Member. Compared with other parts of the Green River Formation, the Douglas Creek Member consists largely of sandstone and limestone, some marlstone, and only a small amount of oil shale. Outcrops of the Douglas Creek Member in Hells Hole Canyon just east of the tracts and in Evacuation Wash just southeast of the tracts reveal that the member is composed primarily of light-yellowish-brown and light-gray oolitic limestone interbedded with gray-to-brown sandstone and siltstone. As shown in Figures 2.2-4 and 2.2-5, this member is not exposed at the surface within the tracts, but lies below depths ranging from approximately 1,250 to 1,750 feet. Maximum thickness attained by this member, beneath the tracts, is about 650 feet.

Garden Gulch Member. The Garden Gulch Member consists primarily of gray and brown marlstone strata containing imbedded organic matter and minor amounts of siltstone, sandstone, and thin beds of oil shale. This member is not exposed on the tracts, but is found below depths ranging from about 800 to 1,250 feet. Its thickness varies from 220 to 250 feet beneath the tracts, as shown in Figures 2.2-4 and 2.2-5.

Parachute Creek Member. The Parachute Creek Member includes the uppermost strata of the Green River Formation, and contains the most economically important sequences of oil shale strata within the Green River Formation. Its lithology is predominantly calcium carbonate mudstone, or marlstone,

and dolomite, containing abundant organic matter interbedded with minor amounts of siltstone, sandstone, and altered volcanic tuff beds. Near the tracts, outcrops along the southeast perimeter of the Uinta Basin attain a maximum thickness of 900 feet, and like the other Tertiary formations in the Uinta Basin, thicken progressively in the subsurface from the vicinity of the tracts toward the northwest. Strata within the upper 200 feet of the Parachute Creek Member are exposed within the eastern portion of the tracts, as shown in Figures 2.2-4 and 2.2-5. Most of the member, however, lies below the surface within the tracts as shown in the geologic cross section. Thickness of the member averages 730 feet beneath the tracts.

The Mahogany Marker (Figure 2.2-6), a persistent and widespread key bed within the Parachute Creek Member, is an analcitized volcanic tuff bed that averages 6 inches in thickness, and lies 9 to 15 feet above the Mahogany bed that contains the richest oil shale beds in the basin. The Mahogany Marker weathers to orange-brown rectangular blocks, whereas the Mahogany bed outcrops as a light-gray-to-tan resistant ledge (Ref. 2-6). This marker bed dips at about 150 to 200 feet per mile to the northwest. The mahogany oil shale zone averages about 100 feet in thickness beneath the tracts, and, as reported by Cleveland-Cliffs Geologic Exploration Program Report (Ref. 2-7), the proposed mining zone will extend from about 20 feet above to 40 feet below the Mahogany Marker.

A remarkably distinctive zone lies near the top of the Parachute Creek Member and is known informally as the "Bird's Nest Zone" because of its many ellipsoidal cavities formed by leaching out of nahcolite, a soluble sodium-bicarbonate mineral, from a matrix of predominantly siltstone and marlstone (Ref. 2-6). This zone is the principal aquifer above the Mahogany Zone in the vicinity of the tracts.

A prominent ledge-forming light-brown sandstone unit that lies immediately above the Bird's Nest Zone is believed to be, according to Cashion (Ref. 2-5), the "horse bench sandstone bed."

LEGEND:

Qal	Alluvium	Quaternary System
Qat	Terrace Deposits	

EROSIONAL UNCONFORMITY

Tua	Unit a	Unita Formation	Tertiary System
Tub	Unit b		
Tgp	Parachute Creek Member	Green River Formation	

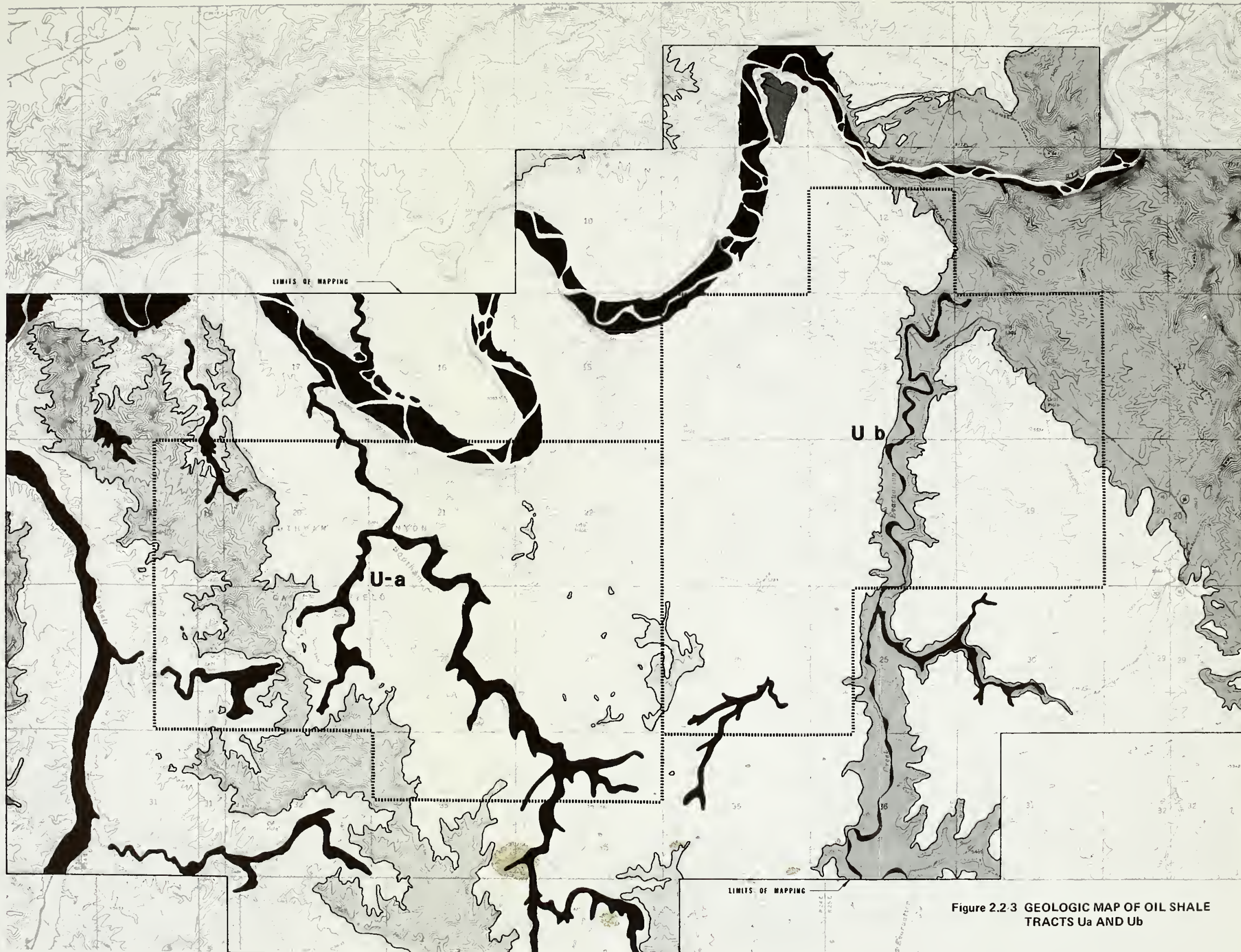
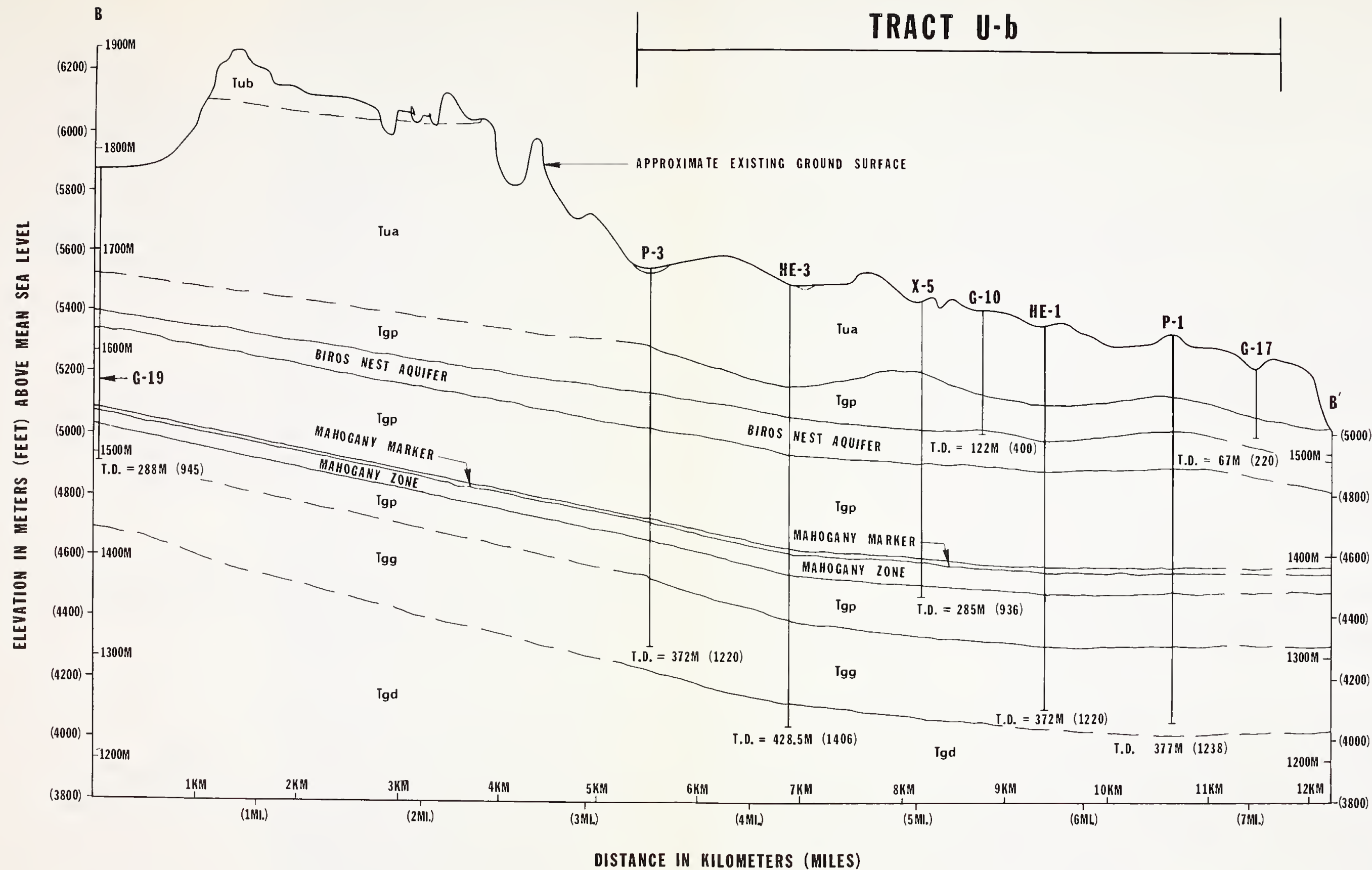


Figure 2.2.3 GEOLOGIC MAP OF OIL SHALE TRACTS Ua AND Ub



LEGEND	
QUATERNARY	
Qal	ALLUVIUM
~	EROSIONAL UNCONFORMITY
TERTIARY	
Tub	UNIT b
Tua	UNIT a
} UINTA FORMATION	
Tgp	PARAGHUTE CREEK MEMBER
Tgg	GARDEN GULGH MEMBER
Tgd	DOUGLAS CREEK MEMBER
} GREEN RIVER FORMATION	
T.D.	TOTAL DEPTH OF BOREHOLE IN METERS (FEET)
X-5	BOREHOLES WITH PROJECT NO. DESIGNATION

NOTE: FORMATION CONTACTS DASHED WHERE INFERRED.

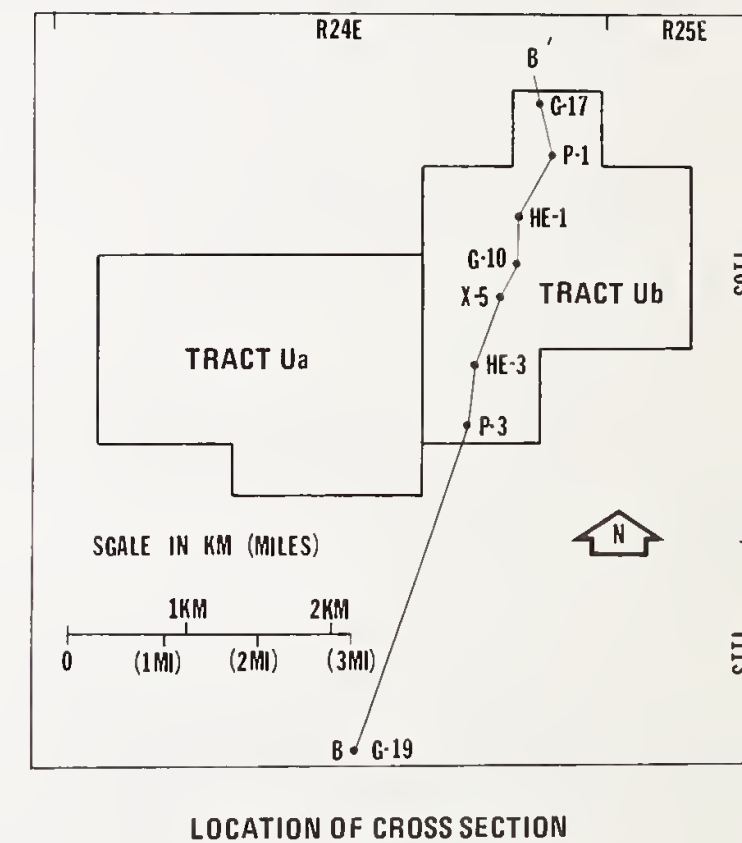
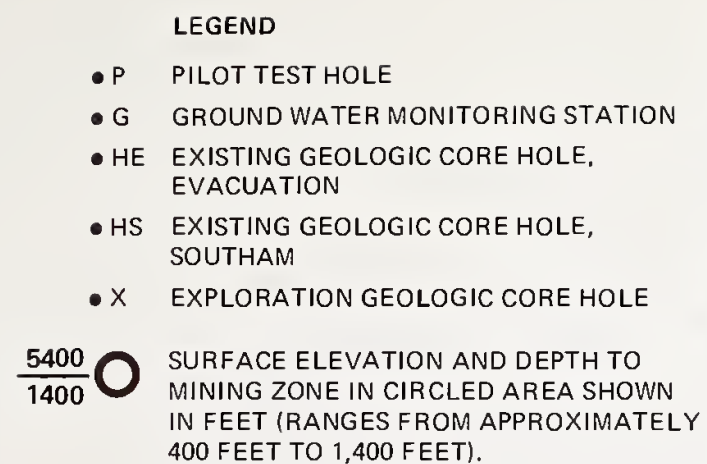


Figure 2.2-5 GEOLOGIC CROSS SECTION THROUGH OIL SHALE TRACT Ub



CONTOUR LINES SHOWING ELEVATION IN METERS (FEET) ABOVE SEA LEVEL OF THE MAHOGANY MARKER BED. A VOLCANIC TUFF BED WHICH LIES APPROXIMATELY 3- 5 METERS (9- 15) FEET ABOVE THE MAHOGANY OIL SHALE BED. CONTOURS DASHED WHERE INFERRED.

NOTE:
X-14 AND X-15 ARE ANGLE HOLES DRILLED 30° FROM VERTICAL. ELEVATIONS SHOWN FOR CORE HOLES X-12 THROUGH X-16 ARE APPROXIMATE.

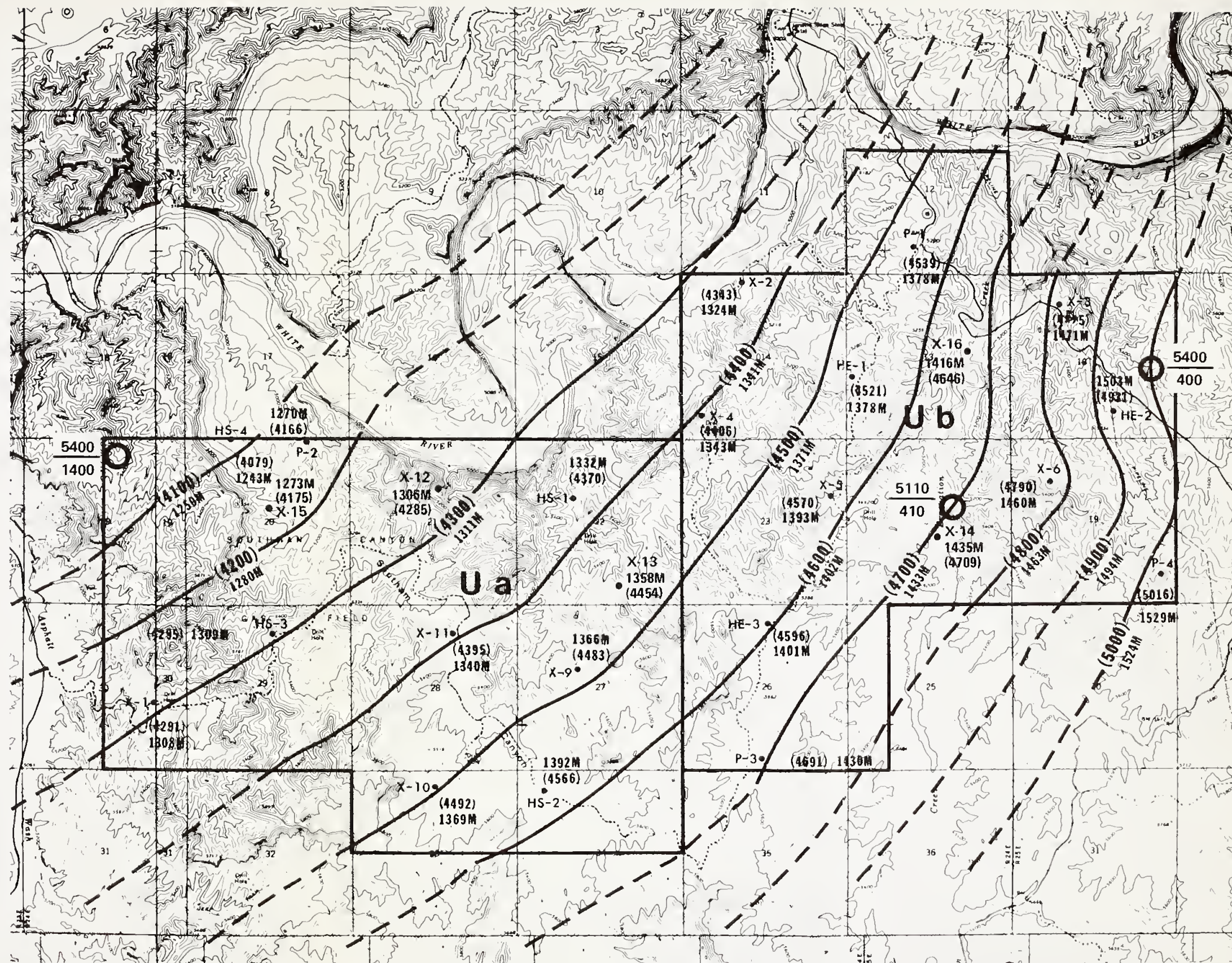
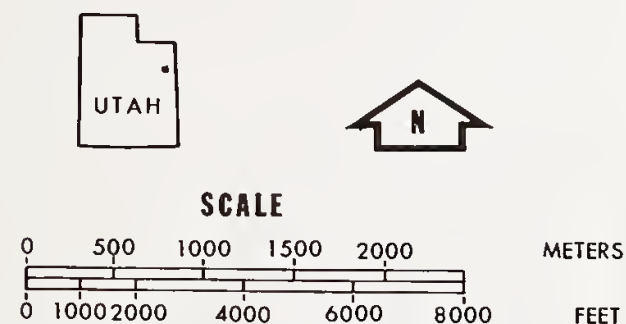


Figure 2.2-6 SUBSURFACE STRUCTURAL CONTOUR MAP OF THE MAHOGANY MARKER BED, TRACTS Ua AND Ub

In the vicinity of the tracts, the horse bench sandstone bed varies from about 2 to 10 feet in thickness. Along Evacuation Creek within the tracts, this unit is composed of very fine sandstone and siltstone. Surface exposures of the horsebench sandstone are typically covered with white salt deposits, thereby suggesting groundwater seepage and evaporation from the outcrops.

2.2.3.2 Uinta Formation

The Uinta Formation, which overlies the Green River Formation, includes the most extensively exposed array of strata in the central Uinta Basin. Like the Green River Formation, the Uinta Formation is of Eocene age. Within Tracts Ua and Ub, the Uinta Formation crops out extensively (Figure 2.2-3) and in places attains a maximum thickness of about 1,000 feet. The formation has been divided by previous investigators into two units, Unit a and Unit b, based primarily upon the position of a tuffaceous sandstone bed approximately 2 to 6 feet thick that lies at the base of Unit b (designated "Tub" in Figure 2.2-3). Unit a, designated "Tua" in Figure 2.2-3, extends downward from the base of Unit b to the top of the Green River Formation. The lithology of both units is generally much the same: stream-deposited, fine-grained, light-reddish-brown sandstone and siltstone interbedded with minor amounts of shale and conglomerate.

2.2.3.3 Quaternary Alluvium

Within Tracts Ua and Ub, quaternary alluvium occurs along Evacuation Creek Canyon, within Southam Canyon, along the White River, and also in some isolated patches along drainages where they pass over outcrops of the Uinta Formation. The geologic map of Tracts Ua and Ub shows areas covered by alluvium (Figure 2.2-3).

The Southam Canyon alluvium is composed primarily of light-reddish-brown silt and fine sand and attains an estimated maximum thickness of about 40 feet. In the southern portion of Southam Canyon at Well Site AG-7, the alluvium is 37 feet. Alluvium in Evacuation Creek Canyon occurs in patches that reach their maximum thickness along the inside and downstream portions

of meander loops of the creek. Estimated maximum thickness of all alluvium along Evacuation Creek Canyon is 21 feet. Since this canyon is being formed by erosion down through the Uinta Formation and into the Green River Formation, the alluvium is composed predominantly of a mixture of coarse-grained, platy marlstone fragments, fine-to-medium sand, and sand-sized limestone fragments. Isolated patches of alluvial material that have been deposited on outcrops of the Uinta Formation are basically light-reddish-brown fine silty sand. Along the White River, the alluvium is primarily light-brown fine sand with some gravel. The maximum thickness of the alluvium along the White River near the tracts is about 35 to 50 feet.

2.2.4 STRUCTURAL GEOLOGY

Geologic structure within the vicinity of the site is quite uniform. The strata generally dip less than 5 degrees (below horizontal) toward the north or northwest, and no surface expression of faulting is exhibited. The Mahogany Marker bed reveals the orientation of strata within the proposed mining zone and generally dips about 150 to 200 feet per mile toward the northwest (Figure 2.2-6).

A surface examination has revealed several sets of near-vertical joints (rock fractures) occurring throughout the site area. Since the joints are very important in the overall strength and stability of the strata, they have been mapped and analyzed in detail. Considering all joints mapped within the entire site area, the primary set trends north 62 degrees west and dips 86 degrees toward the southwest. Three secondary sets are also present, possessing trends that are north 22 degrees east, north 18 degrees east, and north 33 degrees east, with dips that are respectively 88 degrees northwest, 88 degrees southeast, and 87 degrees southeast. The character of the joints that are formed in the Uinta Formation is, as a rule, quite changeable. Smooth, large, flat, open joints are the most noticeable in the field; however, there are also numerous small, rough, closed joints in outcrop exposures throughout the area.

Two inclined core holes were drilled on the tracts to investigate the occurrence of steeply dipping subsurface joints or fractures. Information obtained from the drilling of these two inclined holes, combined with the previous information obtained from vertical drill holes, indicates that the subsurface material comprising the lower part of the Uinta Formation and the upper part of the Green River formation is competent. Frequent parting planes parallel to the bedding are present, particularly in the leaner shale zones, but steeply dipping joints or fractures are rare.

2.2.5 GEOLOGIC HAZARDS

2.2.5.1 Seismicity

Seismic risk is defined as the probability of earthquake damage from ground shaking, subsidence, differential settlement, ground cracking, or liquefaction. Three zones of seismic risk, based on historic earthquake occurrence, have been identified for the western U.S. (Ref. 2-8). Tracts Ua and Ub lie within the lowest risk zone. No active surface faults have been reported in the vicinity of the tracts.

2.2.5.2 Landslides and Rockfalls

Ancient landslides are evident along many of the steep cutbanks of the White River. Examples are evident on the tracts of recent debris flows within steep drainages and rockfalls along sharp ridges. Areas that are particularly susceptible to rockfalls are shaded darkest gray or black on the site slope gradient map (Figure 2.2-2). Severe thunderstorms and accompanying flash floods are the primary forces causing landslides and debris flows.

2.2.6 MINERAL RESOURCES

Economically important deposits of minerals within the Uinta Basin are shown in Figure 2.2-7.

2.2.6.1 Oil and Natural Gas

Altogether there have been eight holes drilled for oil and gas exploration on Tracts Ua and Ub. Only one of these holes, located in the central portion of Tract Ua within Southam Canyon, has produced economically valuable quantities of oil and gas. The other on-tract exploratory holes were dry. Nearby, however, a group of about 14 productive gas wells have been completed and are approximately 4 to 5 miles southwest of Tract Ua. Another three productive gas wells are 1.5 to 3 miles northwest of Tract Ua. Although these wells penetrate the entire thickness of the Eocene strata, the principal productive zone (the Mesa Verde Formation of Cretaceous age) lies considerably deeper in the section.

2.2.6.2 Oil Shale

Oil shale is not shale at all, but is actually a dense, tough, thinly bedded, dark-to-olive-brown to brownish-black marlstone. The organic fraction of oil shale was derived from microorganisms that originally flourished in shallow tropical lakes and from pollen, spores, and fragments of land plants blown into the ancient lake system. The inorganic fraction of the oil shale is composed mainly of dolomite and calcite, with minor amounts of quartz, feldspars, analcite, clay, and pyrite (Ref. 2-9). Analysis also indicated the presence of boron, mercury, cadmium, fluoride, antimony, arsenic, and selenium in trace amounts. Cashion (Ref. 2-6) defined oil shale as marlstone that will yield at least 15 gallons per ton.

2.2.6.3 Gilsonite

Classed as an asphaltite, Gilsonite is a black, tar-like, brittle substance which has been formed as a residue of natural petroleum. Homogeneous veins of Gilsonite occur along straight and continuous northwest-trending joints and minor faults in the east-central Uinta Basin, but primarily within the Uinta Formation.

- LEGEND
- GILSONITE VEINS
1. OIL FIELD
 2. GAS FIELD
 3. BITUMINOUS SANDSTONES OR TAR SANDS
 4. TOTAL THICKNESS OF OIL-SHALE BEDS, IN FEET
 5. NEAR SURFACE, MEDIUM AND HIGH VOLATILE BITUMINOUS COAL SEAMS AT LEAST 14 INCHES THICK
 6. URANIUM DEPOSIT CONTAINING LESS THAN 1000 TONS OF ORE WITH AT LEAST 0.1 PERCENT OF U_3O_8
 7. GYPSUM OUTCROP
 7. NAHCOLITE DEPOSIT, SUBSURFACE LIMITS UNCERTAIN

SOURCES OF INFORMATION:

- 1) OIL AND GAS FIELDS FROM RITZMA, 1972
- 2) OIL-SHALE THICKNESS FROM CASHION, 1964
- 3) BITUMINOUS SANDSTONE LOCATIONS FROM CURTIS, 1972
- 4) COAL FIELDS FROM AVERITT, 1972
- 5) LOCATIONS OF URANIUM DEPOSITS FROM BUTLER, 1972
- 6) GYPSUM AND NAHCOLITE AREAS FROM HITE, 1972
- 7) GILSONITE VEINS FROM W. L. STOKES & J. H. MASDEN, 1961



Figure 2.2-7 MINERAL RESOURCES OF THE UINTA BASIN

Other economic and potentially economic mineral resources found in the Uinta Basin (Figure 2.2-7) include bituminous sandstone, coal, uranium, gypsum, and nahcolite. Only very minute quantities of construction-grade sand and gravel are present on the tracts.

2.2.7 SOILS

2.2.7.1 Regional Soils

The soil associations that occur in Tracts Ua and Ub are #51 and #63, as classified by the Soil Conservation Service. Soils of Association #51 occur along the White River. At this site, they are Aquic Ustifluvents and constitute about 25 percent of Association #51. The remainder of the soils in the tracts are typic Torriorthents, Lithic Calcionthids, and Lithic Natragids. For the major portion of the tracts, Torriorthent soils are more stony than indicated on regional soils maps, while the Natragids soils are less stony than indicated.

2.2.7.2 Soil Types

Twenty-four soil mapping units are shown on the soil map of Tracts Ua and Ub (Figure 2.2-8). Most of the map units are composed of A (5 types), As (5 types), B (3 types), and Bs (6 types) soils. Small areas of D, W, E, F, and N soils and complexes of these are also found.

The soils of Tracts Ua and Ub consist of shallow to very shallow (less than 20 inches deep) soils on sloping to steep upland surfaces cut by numerous intermittent drainages and containing many areas of rock outcrops and rock escarpments.

Soils A, As, B, Bs, and F are included in these shallow sites. They consist of sandy loam, loams, channery sandy loams, and channery loams. The content of coarse fragments (channers and flaggs) usually increases with depth, and numerous flagstones, with a small proportion of soil, may be found immediately above the bedrock. Surface soils are light-colored and moderately calcareous. The CaCO_3 (lime) content as a rule increases with depth and occurs as a coating on the undersides of rock fragments.

Numerous drainage courses are found throughout the tracts. Most of these have intermittent stream channels, and the soils along these channels are generally deep (more than 60 inches). The D soils occur in these areas and are most extensive in the Southam Canyon drainage area. They are mainly sandy loams or channery sandy loams, light-colored and moderately calcareous.

Along the Evacuation Creek drainage, the D soils are associated with N soils. The latter are deep, moderately fine-textured, and strongly alkaline, with a high concentration of exchangeable sodium. The N soils also are found on stream terraces about 50 to 1,000 feet above the White River floodplain. In these areas the N soils occur with E soils. The E soils are deep, moderately coarse-textured, with a strong CaCO_3 (lime) horizon in the subsoil.

W soils occur adjacent to the White River, mainly in the corridor outside Tracts Ua and Ub. These are deep, silty soils that are seasonally wet in deeper horizons and generally have a high salt content.

2.2.7.3 Soil Infiltration

A soil infiltration study was conducted to provide baseline data for the evaluation of major effects to the soil as a result of land use changes, and to provide information for Soil Conservation Service (1972) modeling of surface water runoff.

Because of the limited ability of a small portable infiltration test device to replicate actual conditions, the data furnished are best if used as a comparison between soil types.

Upland soils have infiltration rates of 1.4 inches per hour, and bottom-lands soils (D soils) have rates of about 2.4 inches per hour. The soils formed on the alluvium of the White River (W soil) have much slower rates of uptake, about 0.6 inch per hour, because of their high silt and clay

LEGEND

- A(1-5) — SHALLOW CHANNERY LOAMS, 3 TO 40 PERCENT SLOPES
- As(1-5) — SHALLOW CHANNERY SANDY LOAMS, 5 TO 60 PERCENT SLOPES
- B(1-3) — SHALLOW CHANNERY AND FLAGGY LOAMS, 5 TO 40 PERCENT SLOPES
- Bs(1-6)(R) — SHALLOW CHANNERY AND FLAGGY SANDY LOAMS, 10 TO 60 PERCENT SLOPES
- Ds(D) — SANDY LOAMS, 5 TO 10 PERCENT SLOPES
- E (EN) — DEEP LOAMS, 5 TO 10 PERCENT SLOPES
- F (FR) — SHALLOW LOAMS SANDS, 3 TO 7 PERCENT SLOPES
- N (NE, BD) — DEEP, MODERATELY FINE TEXTURED SOIL, 5 TO 10 PERCENT SLOPES
- W — DEEP SILTY ALLUVIUM, 0 TO 2 PERCENT SLOPES



PHOTO MOSAIC; NOT TO SCALE

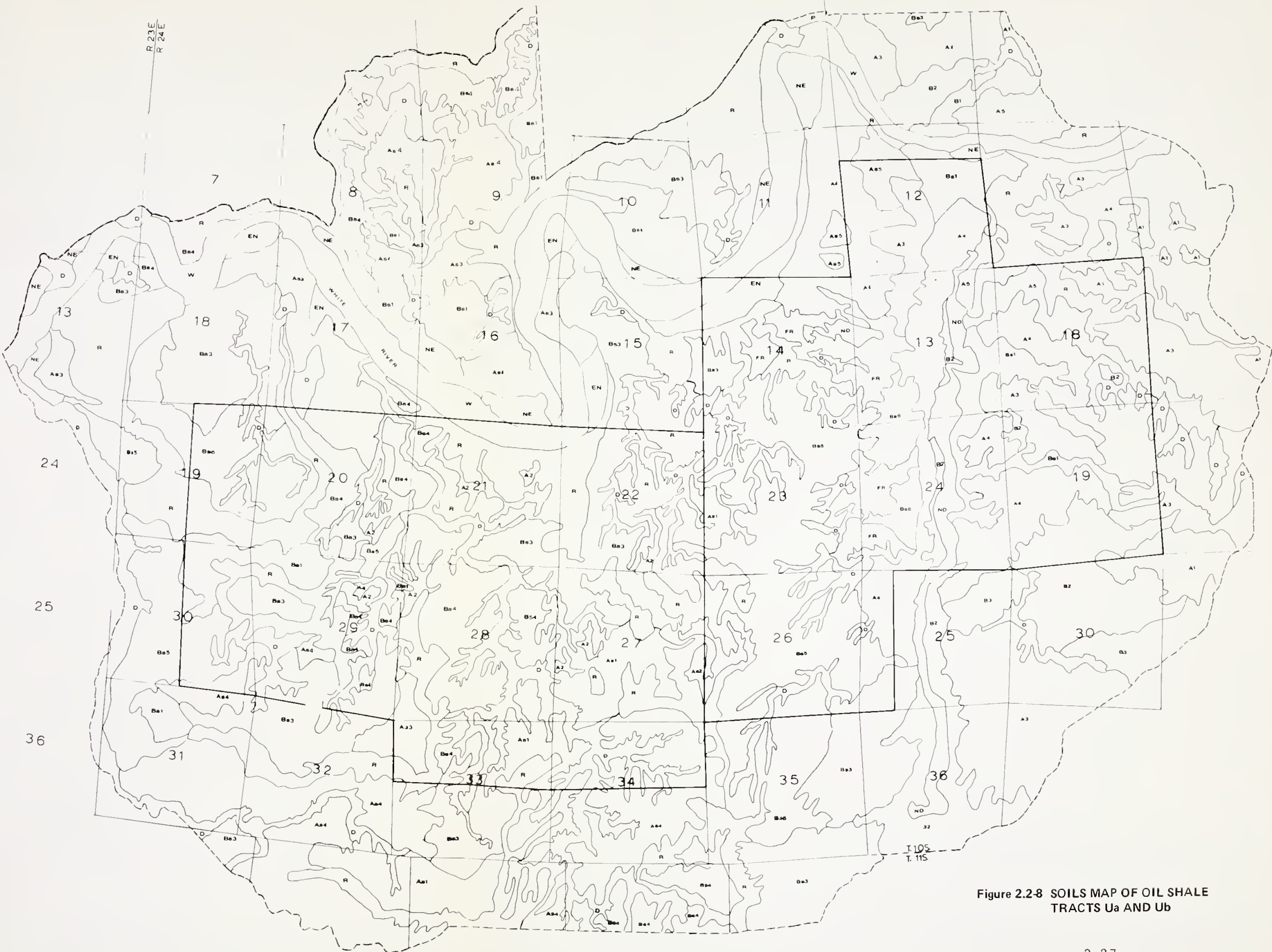


Figure 2.2-8 SOILS MAP OF OIL SHALE TRACTS Ua AND Ub

content. As would be expected, soils affected by excess sodium (N soil) have the lowest infiltration rates, about 0.3 inch per hour.

Infiltration rates did not decrease dramatically during the 28-minute period of the test. Most runs showed no time trend. A few runs had a small initial decrease with time. In addition, soil type was apparently more significant in determining infiltration rates than slope angle. Infiltration rates from test plots on dry soils were generally about 1 inch per hour greater than the rates on wet soils.

2.2.7.4 Soils Engineering Properties and Interpretations

Many properties of soil, such as permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction, are important to engineering uses. Also important are slope, depth to bedrock, and depth to the water table. Engineering data and interpretations for the soils are presented in Tables 2.2-1 and 2.2-2.

The Unified and AASHTO Engineering Classification Systems show that most of the soils within the tracts have relatively high bearing strengths. E, N, and W soils, however, are not desirable as base material in construction. All soils except E, N, and W are nonplastic.

Permeability for most of these soils is moderate to moderately rapid, but for the N soils, permeability is slow. Available water capacity for these soils is rather low. The pH values indicate that the soils are mildly to strongly alkaline. Electrical conductivities (EC in mmhos/cm) indicate a wide range in the salinity of most of these soils (0.3 to 28.0 mmhos/cm). Shrink-swell potentials are low, with the exception of the N and W soils, which have moderate shrink-swell potentials. Runoff potentials of the soils vary from moderately low to high.

Owing to their shallowness and excessive slopes, the A, As, B, and Bs soils are unsuited for septic tank absorption fields, sewage lagoons, or sanitary

Table 2.2-1

ESTIMATED AND MEASURED SOIL PROPERTIES SIGNIFICANT TO ENGINEERING NEEDS

Soil	Slope Range (%)	Depth to Bedrock (cm)	Texture Class	Unified Class.	AASHTO Class.	Liquid Limit	Plastic Limit	Permeability (in./hr)	Water Capacity Available (in./in.)	pH	Electrical Conductivity (mmhos/cm)	Shrinkage - Soil - potential	Hydrologic Soil Group
A	3 to 40	30 to 50	Clannery loam	SM GC	A-2-4	24-33	NP-0	1.0-2.5	0.9-0.11	7.5-8.7	0.4-5.4	Low	C (moderately high level of potential)
As	5 to 60	30 to 50	Clannery sandy loams	SM GM	A-2-4	24-36	NP	1.5-3.0	<0.1	8.1-8.5	0.1-6.0	Low	C (moderately high level of potential)
*B	5 to 40	5 to 25	Clannery loams	SM GM	A-2-4	20-30	NP	1.0-2.5	<0.1	7.5-8.2	0.7-3.0	Low	D (highly consistent potential)
*Bs	10 to 60	5 to 25	Clannery sandy loams	SM GM	A-2-4	20-30	NP	1.5-3.0	0.1	7.5-8.3	0.7-2.5	Low	D (highly consistent potential)
Bs	5 to 10	150+	Sandy loam to clannery sandy loam	SM	A-2-4	20-21	NP	1.0-2.5	0.12-0.14	7.9-8.1	1.0-19.0	Low	B (moderately low potential)
B	5 to 10	150+	Fine sandy loams to loams	M I, C, 1 SM	A-4 A-6	20-27	NP-8	1.0-2.5	0.14-0.16	7.7-8.6	0.4-18.0	Low	B (moderately low potential)
*F	3 to 7	10 to 40	loamy sands	SM	A-2	20-30	NP	2.0-4.0	<0.1	8.1-8.5	0.9-0.6	Low	D (highly consistent potential)
*N	5 to 10	150+	Fine sandy loam surface, silty clay loam subsoil	CL	A-4 or A-6	20-30	5-15	0.05-0.20	0.14-0.16	8.1-8.9	5.0-15.0	Moderate	D (highly consistent potential)
*W	0 to 2	150+	Silt loams to silty clay loams - some sands	CL SM	A-4 A-6	20-47	2-16	0.80-2.0	0.16-0.18	8.0-8.1	1.5-28.0	Moderate	B (moderately low potential)

*Field estimate

Table 2.2-2

INTERPRETATIONS OF ENGINEERING
PROPERTIES OF SOILS

Soil	Degree/Kind of Limitation for ^(a)								Suitability as a Source of					
	Septic Tank Absorption Fields	Sewage Lagoons	Sanitary Landfill		Shallow Excavations	Dwellings w/without Basements		Local Roads and Streets	Roadfill	Sand	Gravel	Topsoil	Sanitary Landfill Cover Materials	Cover Processed Shale Deposit
			Trench Type	Area Type										
A	Severe/ slope depths	Severe/ slope depths	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Good to fair, A-2-4	Unsuited, loam	Poor, loam, shallow	Poor, channery and flaggy	Poor, shallow	Poor, shallow
As	Severe/ slope depth	Severe/ slope depth	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Good to fair, A-2-4	Unsuited, sandy loam	Poor, sandy loam, shallow	Poor, very channery and flaggy	Poor, shallow	Poor, shallow
B	Severe/ slope depth	Severe/ slope depth	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Good to fair, A-2-4	Unsuited, loam	Poor, loam, shallow	Poor, very channery and flaggy	Poor, very shallow	Poor, very shallow
Bs	Severe/ slope depth	Severe/ slope depth	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Severe/ depth slope	Good to fair, A-2-4	Unsuited, sandy loam	Poor, sandy loam, shallow	Poor, very channery and flaggy	Poor, very shallow	Poor, very shallow
Ds	Slight/ 5 to 10% slopes	Moderate/ 5 to 10% slope	Slight	Slight	Slight	Slight	Slight	Slight	Good to fair, A-2-4	Unsuited, sandy loam	Unsuited	Fair, channer content increases with dept ¹	Fair to good	Fair to good
E	Slight/ 5 to 10% slope	Moderate/ 5 to 10% slope	Slight	Slight	Slight	Slight	Slight	Slight to moderate/ A-6 material in subsoil	Fair, A-4 A-6	Unsuited sandy loam and loam	Unsuited	Fair to 20 cm	Fair to good	Fair to good
F	Severe/ depth	Severe/ depth	Severe/ depth	Severe/ depth	Severe/ depth	Severe/ depth	Severe/ depth	Severe/ depth	Fair, A-4	Poor, shallow loamy sand	Unsuited	Poor, shallow loamy sand	Poor, shallow loamy sand	Poor, shallow
N	Severe/ moderately slow per- meability	Severe/ moderately slow per- meability	Moderate/ moderately slow per- meability	Moderate/ moderately slow per- meability	Slight	Moderate/ moderate shrink- swell	Moderate/ moderate shrink- swell	Moderate/ moderate shrink- swell	Fair to poor, A-4 A-6	Unsuited, silty clay loam	Unsuited	Poor, alkaline salts	Poor, alkaline salts	Poor, alkaline salts
W	Severe/ seasonal high water table, flood danger	Severe/ seasonal high water table, flood danger	Severe/ seasonal high water table, flood danger	Severe/ seasonal high water table, flood danger	Moderate/ seasonal high water table, flood danger	Severe/ flood danger, seasonal high water table	Severe/ flood danger, seasonal high water table	Severe/ flood danger, seasonal high water table	Fair to poor, A-4 A-6	Poor, silt loam, inclusive of fine sand	Unsuited	Good silt loam, poor fine sand	Good	Fair, high salt content in subsoil

(a) Degree refers to the overall limitations of the soil type.
Kind refers to parameters that cause limitations.

landfills. F soils are also unsuited because of shallowness, while W soils are unsuited because of seasonal high water table and flood hazard. N soils have some limitations for these uses, because of moderately slow permeability and moderate shrink-swell potential. The Ds and E soils have few limitations and are suitable for these uses.

The A, As, B, Bs, and Ds soils are good to fair as a source of roadfill. The E, F, N, and W soils are fair to poor for roadfill use. All of these soils are poor or unsuitable as sources of sand and gravel.

Soils D and W are the best source of topsoil. The Southam Canyon area, where the processed shale will be deposited, contains about 640 acres of D soils. The W soils are most commonly found along the White River Valley.

2.2.7.5 Soil Radioactivity

Measurements of soil radioactivity were made in order to establish baseline levels of radioactivity in the area, and to separate the contributions from: 1) radioactivities originating from nuclides within the oil shale (usually from nuclides in a uranium decay chain, which could affect the environment), 2) naturally occurring background activity, and 3) radioactivity identified with the worldwide fallout from weapons testing. The radiation levels in the soils of the tracts are primarily associated with sources of nuclear radiation from the naturally occurring background activity. The results are viewed from this perspective.

A number of soil samples were collected from representative locations on the two lease tracts and analyzed for radioactivity. No sources above a normal background level were identified, with Ra²²⁶ activity below 0.87 pCi/g, Sr⁹⁰ below 0.52 pCi/g, K⁴⁰ below 20 pCi/g, Pb²¹² below 1.5 pCi/g, and Cs¹³⁷ below 1.6 pCi/g for all samples.

2.3 WATER RESOURCE

2.3.1 SURFACE WATER

2.3.1.1 Surface Water Hydrology

The streams in the vicinity of Tracts Ua and Ub are part of the White River Basin, which is a major subbasin of the Green River. Most of the flow of the White River originates from the mountainous area in western Colorado above Meeker, called the Flat Tops. Section 3.14 discusses stream flows along the White River in more detail. As the river flows westward, only minor additions are made in the lower 80 percent of the drainage area between the headwaters in the mountains and the confluence with the Green River. The lower portion of the White River Basin has a few perennial streams, and near the tracts, only Evaluation Creek flows continually (in its lower reaches) during most of the year. Other major drainages in this area — Asphalt Wash, Southam Canyon, and Hells Hole Canyon — are ephemeral and flow only in response to snowmelt or rainfall events. The flow and water quality of streams in the vicinity of the tracts have been investigated in detail during recent years (1974 to the present) as part of the baseline study and extended monitoring programs for this project, along with other studies by the U.S. Geological Survey (USGS). The surface water monitoring locations are shown in Figure 2.3-1.

White River. Above the study area, the White River has a drainage area of about 4,000 square miles. At the USGS gauging station 09306500 (near the White River bridge south of Bonanza) the mean annual flow was 695 cubic feet per second (cfs) during the 1923-1979 period. Figure 2.3-2 illustrates the hydrographs from October 1974 to September 1979 (water years 1975-1979) at station 09306500. Table 2.3-1 summarizes the streamflow records for water years 1975-1979 and the period of record. During most of the year, streamflow is sustained by a relatively stable baseflow (200-500 cfs). Peak flow usually occurs from mid-May through mid-July from snowmelt runoff in the upper watershed. A drought in 1977 resulted in very low streamflow during the summer months, reaching a mean daily flow of only 13 cfs on July 4.

LEGEND:

- STREAMFLOW GAUGING STATION
AND WATER QUALITY SAMPLING
STATION

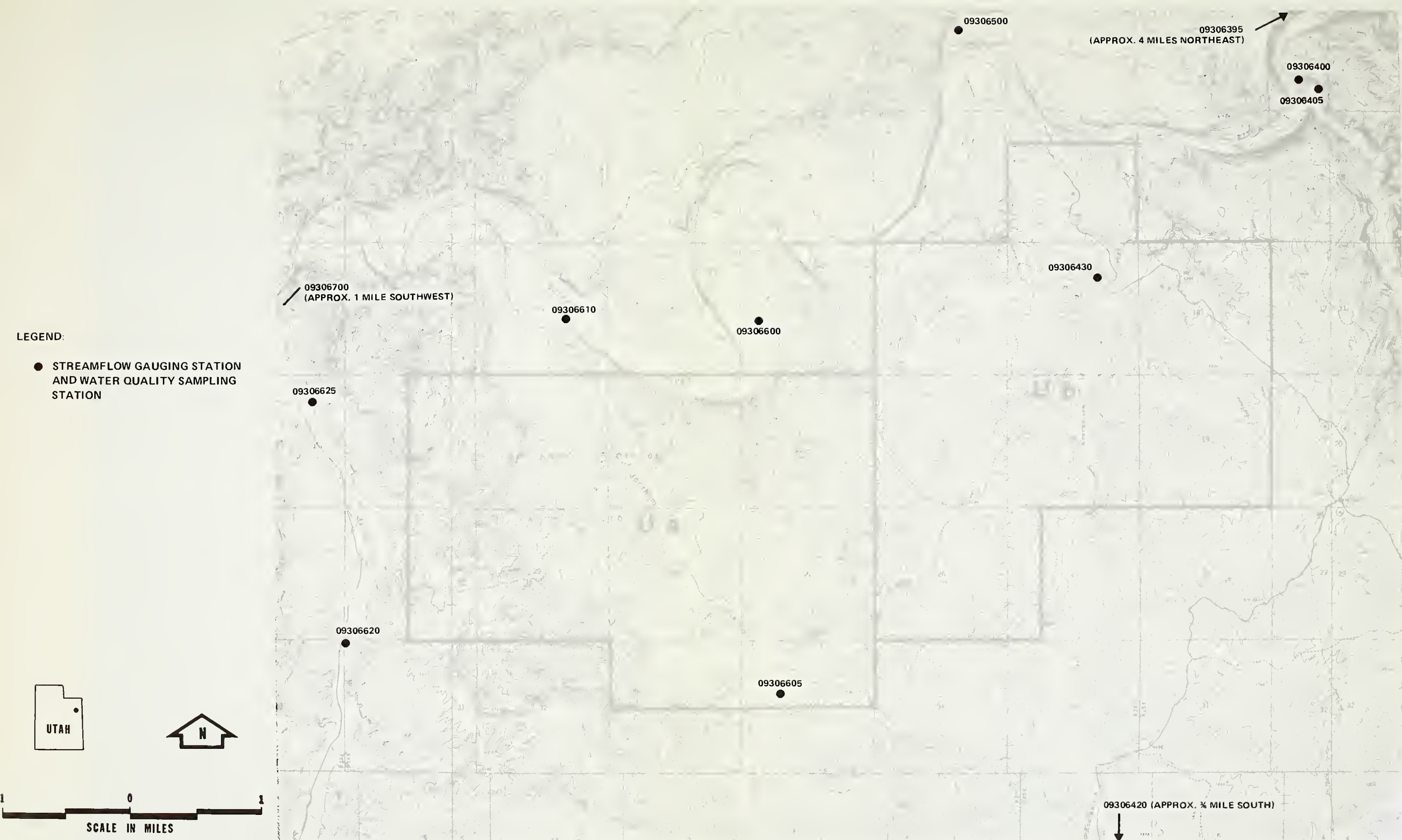


Figure 2.3-1 MONITORING LOCATIONS OF
SURFACE WATER

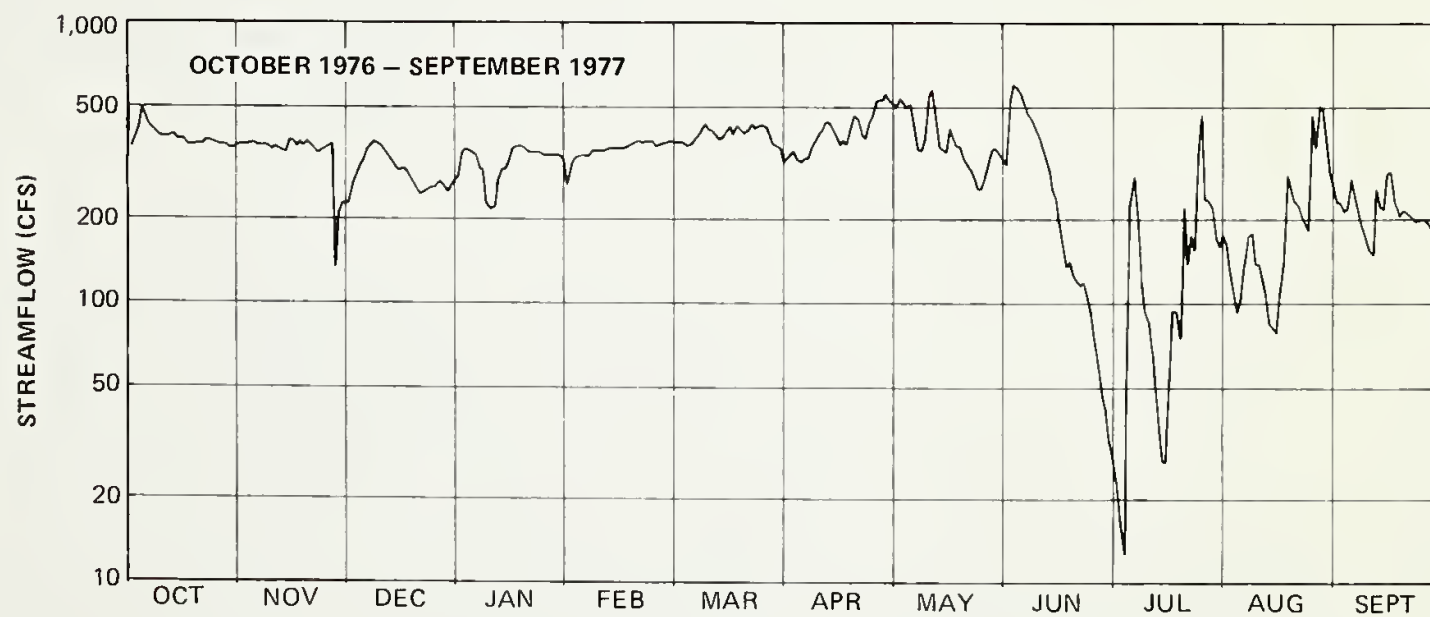
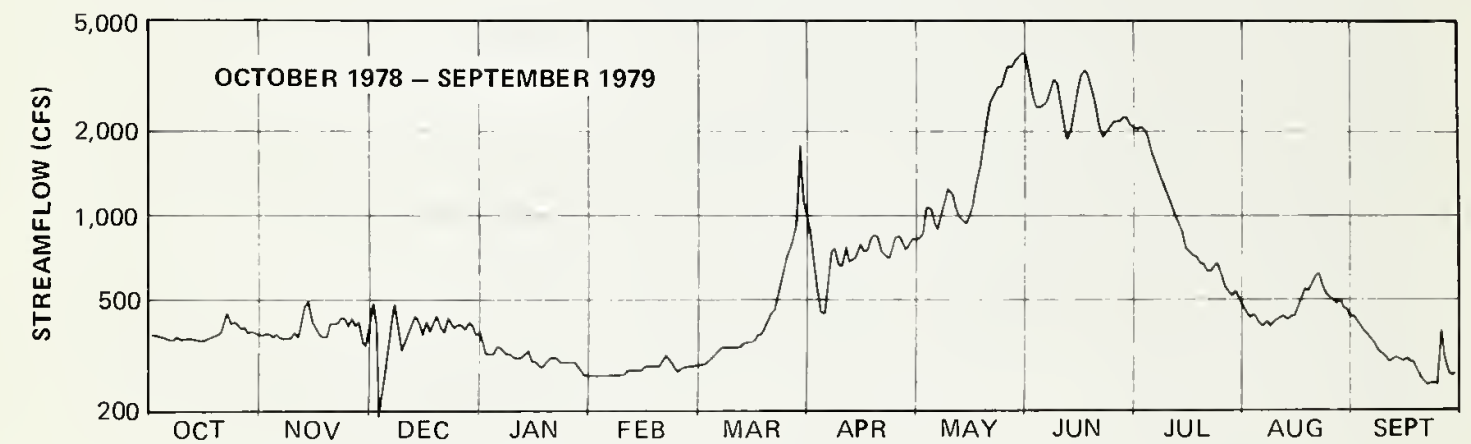
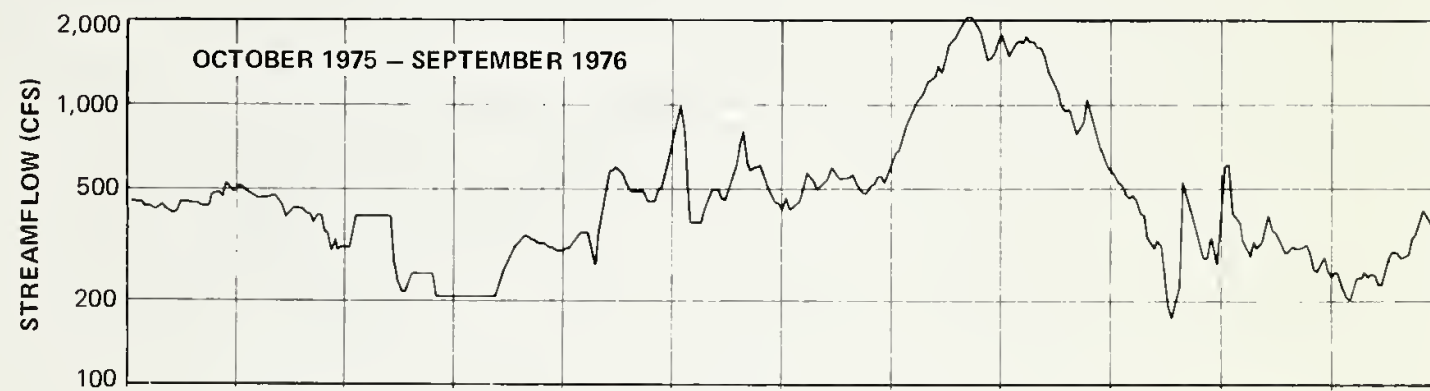
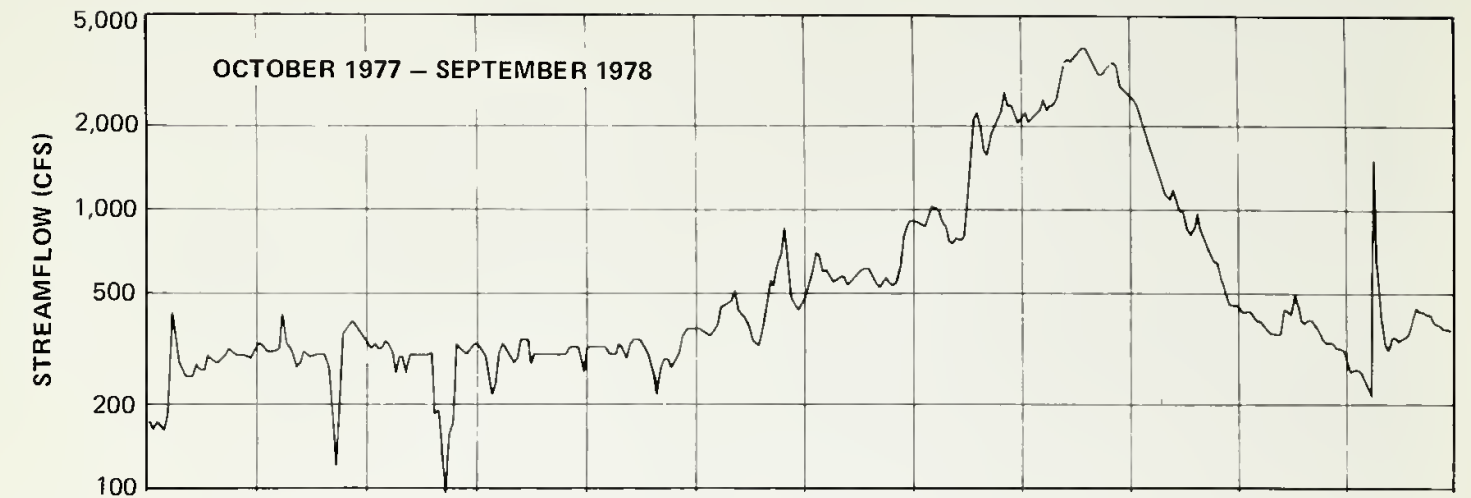
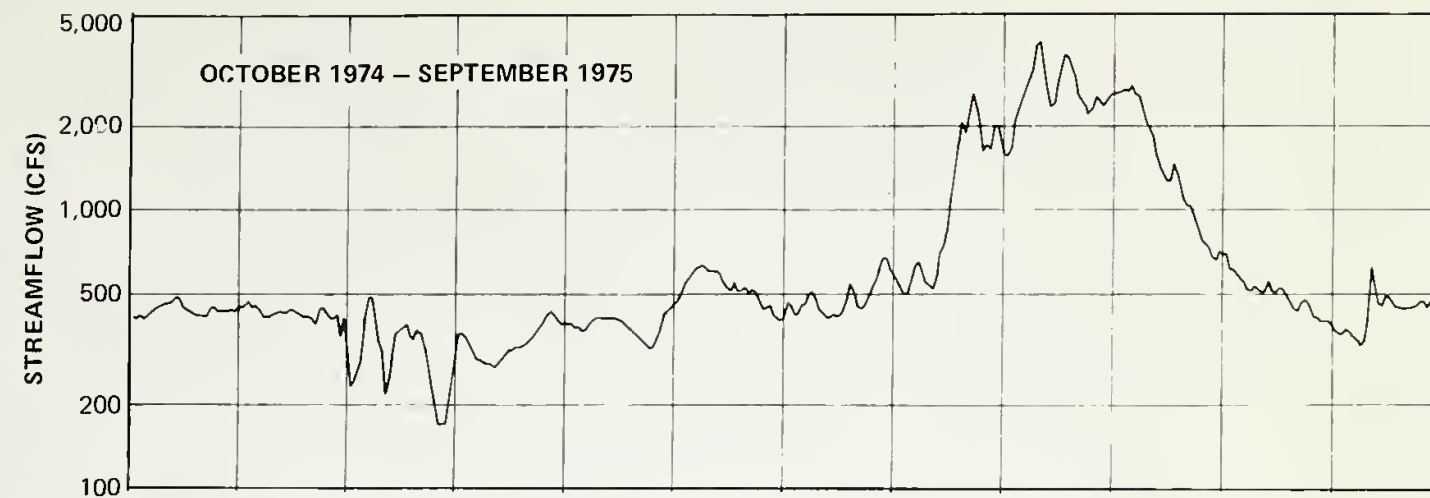


Figure 2.3-2 MEAN DAILY STREAMFLOW OF WHITE RIVER
NEAR WATSON (STATION 09306500)

Table 2.3-1

SUMMARY OF STREAMFLOW RECORDS AT WHITE RIVER NEAR WATSON, UTAH
WATER YEARS 1975-1979 AND PERIOD OF RECORD (1923-79)
(Station 09306500)

Stream	Units	Water Year (a)					Period of Record
		1975	1976	1977	1978	1979	
Mean Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{21.8}{772}$	$\frac{15.5}{546}$	$\frac{8.72}{308}$	$\frac{20.8}{735}$	$\frac{21.7}{767}$	$\frac{19.7}{695}$
Maximum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{111}{3910}$	$\frac{58.0}{2050}$	$\frac{17.0}{602}$	$\frac{108}{3800}$	$\frac{108}{3820}$	$\frac{231}{8160}$ (b)
Maximum Instantaneous Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{118}{4150}$	$\frac{60.9}{2150}$	$\frac{37.1}{1310}$	$\frac{111}{3910}$	$\frac{110}{3900}$	(b)
Minimum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{4.81}{170}$	$\frac{4.90}{173}$	$\frac{0.37}{13}$	$\frac{2.72}{96}$	$\frac{5.38}{190}$	$\frac{0.37}{13}$
Minimum Instantaneous Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{3.06}{108}$	$\frac{4.73}{167}$	$\frac{0.34}{12}$	$\frac{2.69}{95}$	—	$\frac{0.31}{11}$
Total Annual Runoff	$\frac{\text{ha-m}}{\text{acre-ft}}$	$\frac{68,930}{588,800}$	$\frac{48,930}{396,700}$	$\frac{27,530}{223,300}$	$\frac{65,660}{532,300}$	$\frac{68,460}{555,000}$	$\frac{62,100}{503,500}$

(a) A water year is the twelve-month period from October 1 through September 30.

(b) The maximum instantaneous discharge on this day (July 15, 1929) is not available.

This daily value is greater than all other instantaneous discharge values during the period of record.

Since little flow is contributed to White River from the drainages near the tracts, peak flows are generated primarily by either rapid snowmelt in the upper watershed or relatively widespread intense convective storms. The 100-year, one-day high flow is estimated to be 5,180 cfs, and the 10-year, 7-day low flow is estimated to be 125 cfs, based on the period of record at station 09306500 through the 1979 water year.

Evacuation Creek. The drainage area of Evacuation Creek is approximately 280 square miles, with an elevation change from 5,100 feet at its mouth to nearly 8,000 feet at its headwaters in western Colorado. The hydrographs for water years 1975-1979 at station 09306430 near the mouth of Evacuation Creek are shown in Figure 2.3-3. Also, the streamflow records for this station are summarized in Table 2.3-2. Snowmelt runoff generally has occurred from February through June. During the remainder of the year, the streamflow is generally quite low (less than 1 cfs) and is sustained by groundwater discharge from the Bird's Nest Aquifer. The highest streamflow has occurred in response to intense thunderstorm runoff in the summer months, but these flow events are generally of short duration. The creek is perennial along some reaches (e.g., near the mouth); however, there were occasions during the baseline study when there was no flow. These occurred during the base-flow period and lasted for only a few days. The maximum instantaneous flow during the five years of record was 1,980 cfs. An accurate estimate of the 100-year peak flow value cannot be made based on site-specific flow records because the five-year period of record is not of sufficient length.

Southam Canyon. Southam Canyon has a drainage area of 9 square miles. As can be expected for a small basin, flow is very infrequent and has a high degree of variation from year to year. The streamflow records for station 09306610 at the mouth of Southam Canyon during water years 1975-1979 are shown in Table 2.3-3. The maximum instantaneous flow over the five years of record was 392 cfs.

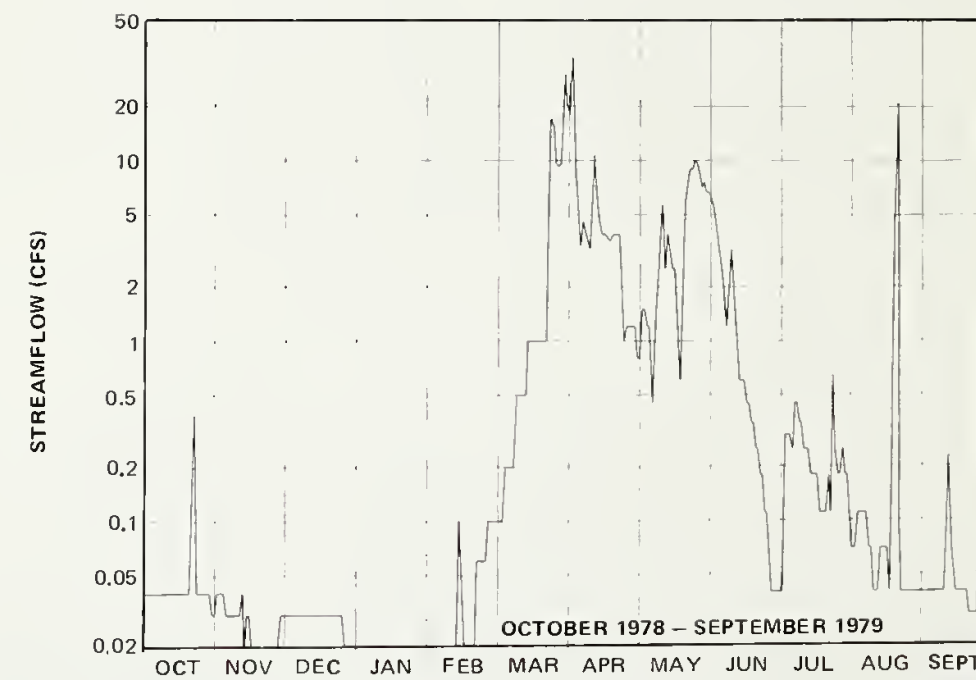
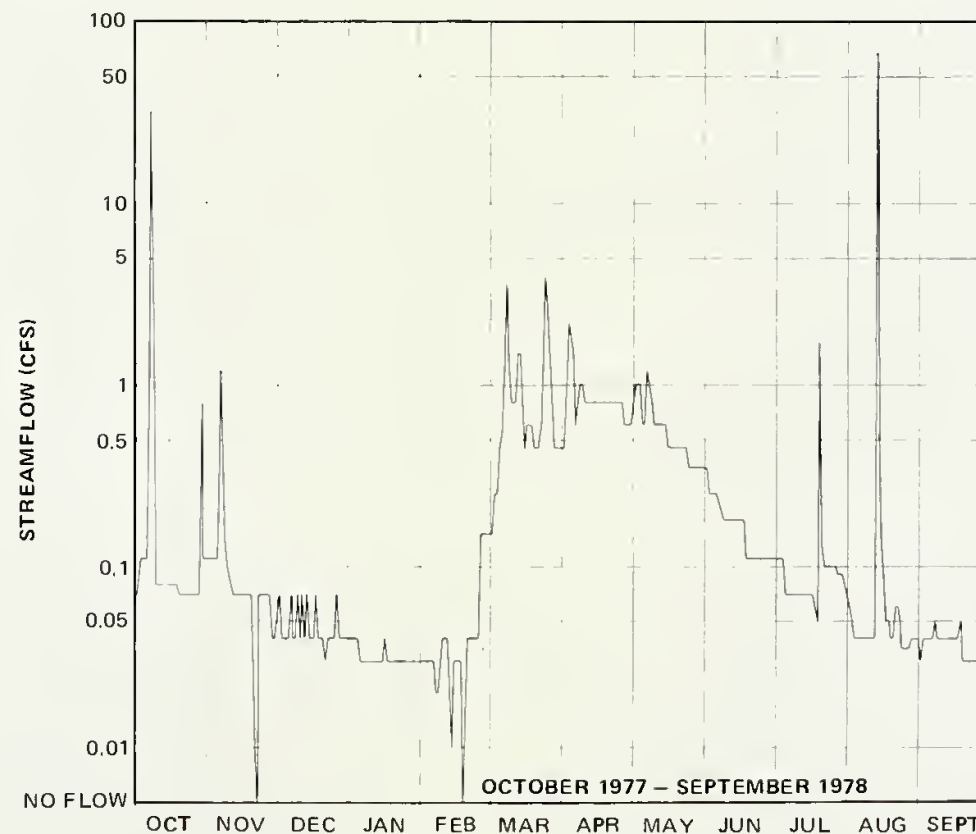
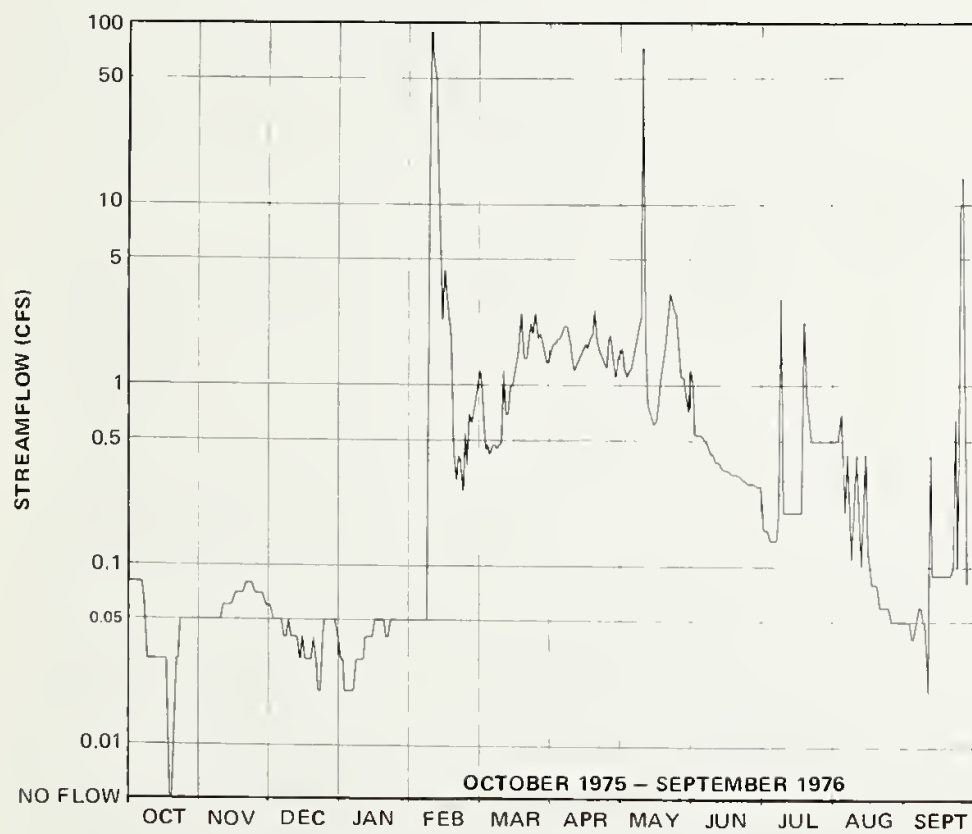
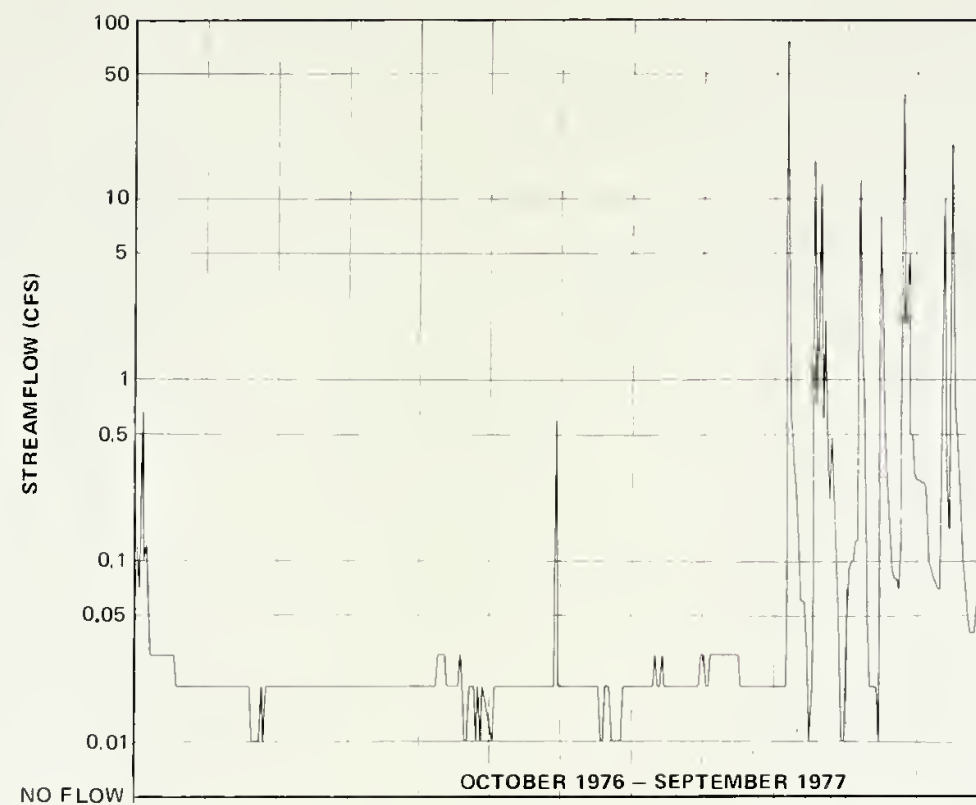
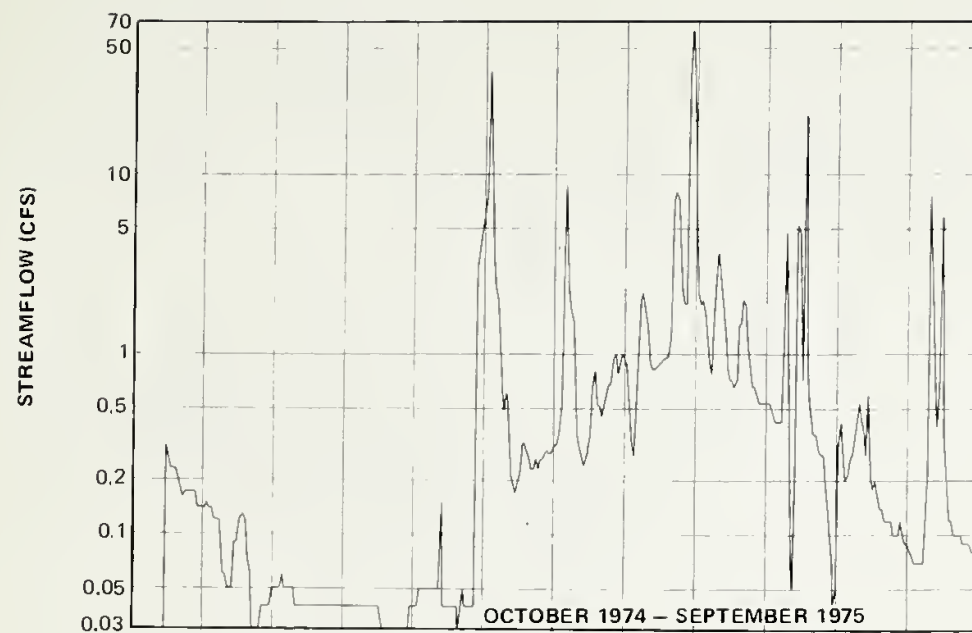


Figure 2.3-3 MEAN DAILY STREAMFLOW OF EVACUATION CREEK NEAR WATSON (STATION 09306430)

Table 2.3-2

SUMMARY OF STREAMFLOW RECORDS AT EVACUATION CREEK NEAR WATSON, UTAH
WATER YEARS 1975-1979
(Station 09306430)

Stream	Units	Water Year				
		1975	1976	1977	1978	1979
Mean Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.032}{1.13}$	$\frac{0.044}{1.54}$	$\frac{0.019}{0.68}$	$\frac{0.017}{0.60}$	$\frac{0.046}{1.62}$
Maximum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{1.76}{62}$	$\frac{2.49}{88}$	$\frac{2.12}{75}$	$\frac{1.87}{66}$	$\frac{1.67}{59}$
Maximum Instantaneous Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{3.06}{108}$	$\frac{19.2}{679}$	$\frac{18.4}{648}$	$\frac{36.8}{1300}$	$\frac{56.1}{1980}$
Minimum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.001}{0.03}$	$\frac{0.00}{0.00}$	$\frac{0.0003}{0.01}$	$\frac{0.00}{0.00}$	$\frac{0.0006}{0.02}$
Total Annual Runoff	$\frac{\text{in-m}}{\text{acre-ft}}$	$\frac{101}{817}$	$\frac{138}{1120}$	$\frac{60.4}{490}$	$\frac{53.9}{437}$	$\frac{144}{1170}$

Table 2.3-3

SUMMARY OF STREAMFLOW RECORDS AT SOUTHAM CANYON WASH AT MOUTH, NEAR WATSON, UTAH
WATER YEARS 1975-1979
(Station 09306610)

Stream	Units	Water Year				
		1975	1976	1977 (a)	1978 (a)	1979 (a)
Mean Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.0016}{0.058}$	$\frac{0.00020}{0.0070}$	$\frac{0.000048}{0.0017}$	$\frac{0.000006}{0.0002}$	$\frac{0.00042}{0.015}$
Maximum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.13}{4.7}$	$\frac{0.051}{1.8}$	$\frac{0.016}{0.57}$	$\frac{0.002}{0.07}$	$\frac{0.13}{4.7}$
Maximum Instantaneous Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.85}{30}$	$\frac{0.74}{26}$	$\frac{0.74}{26}$	$\frac{0.12}{4.2}$	$\frac{11.1}{392}$
Minimum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$
Total Annual Runoff	$\frac{\text{ha-m}}{\text{acre-ft}}$	$\frac{5.2}{42}$	$\frac{0.63}{5.1}$	$\frac{0.15}{1.2}$	$\frac{0.017}{0.14}$	$\frac{1.4}{11}$

(a) Incomplete record for year.

Asphalt Wash. Asphalt Wash has a drainage area of 100 square miles. Table 2.3-4 summarizes the streamflow records for station 09306625 near the mouth of Asphalt Wash during water years 1975-1979. The maximum instantaneous flow during these five years was 123 cfs.

Hells Hole Canyon. The drainage area of Hells Hole Canyon is 26 square miles. The streamflow records for station 09306405 at the mouth of the canyon during water years 1975-1979 are summarized in Table 2.3-5. The maximum instantaneous flow during the five years of record was 473 cfs.

2.3.1.2 Surface Water Quality

White River. During March and April, a significant portion of the flow of the White River is composed of snowmelt from the lower tributaries of the White River Basin. The quality of this water is somewhat variable, but generally has moderate concentrations of dissolved solids (500 mg/l to 700 mg/l) and high concentrations of suspended sediment (600 mg/l to 3,000 mg/l). From May through July, most of the flow of the White River is composed of snowmelt runoff from the uppermost reaches of the White River drainage. This water typically has low concentrations of dissolved solids (200 mg/l to 400 mg/l) but has high concentrations of suspended sediment (800 mg/l to 7,000 mg/l). During the remainder of the year, the flow is sustained primarily by groundwater discharge. This water, referred to as baseflow, also has moderate concentrations of dissolved solids (450 mg/l to 650 mg/l), but has lower concentrations of suspended sediment (100 mg/l to 500 mg/l).

During the water years 1975 through 1979, the maximum value of dissolved solids was 924 mg/l at station 09306395. This occurred during a period of extremely low flow in July 1977. The maximum value of mean daily suspended sediment concentration during water years 1975 through 1979 was 61,000 mg/l, also at station 09306395. This occurred on September 8, 1978 and was caused by a relatively large flash flood.

Table 2.3-4

SUMMARY OF STREAMFLOW RECORDS AT ASPHALT WASH NEAR MOUTH, NEAR WATSON, UTAH
WATER YEARS 1975-1979
(Station 09306625)

Stream	Units	Water Years				
		1975	1976	1977	1978	1979
Mean Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.00071}{0.025}$	$\frac{0.0011}{0.038}$	$\frac{0.00034}{0.012}$	$\frac{0.00008}{0.003}$	$\frac{0.0054}{0.19}$
Maximum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.13}{4.7}$	$\frac{0.12}{4.4}$	$\frac{0.088}{3.1}$	$\frac{0.019}{0.68}$	$\frac{0.45}{16}$
Maximum Instantaneous Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{3.48}{123}$	$\frac{2.69}{95}$	$\frac{1.8}{65}$	$\frac{0.14}{4.8}$	$\frac{2.86}{101}$
Minimum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$	$\frac{00.0}{00.0}$
Total Annual Runoff	$\frac{\text{ha-m}}{\text{acre-ft}}$	$\frac{2.2}{18}$	$\frac{3.3}{27}$	$\frac{1.0}{8.4}$	$\frac{0.23}{1.9}$	$\frac{16.7}{135}$

Table 2.3-5

SUMMARY OF STREAMFLOW RECORDS AT HELLS HOLE CANYON CREEK AT MOUTH, NEAR WATSON, UTAH
 WATER YEARS 1975-1979
 (Station 09306405)

Stream	Units	Water Year				
		1975	1976 (a)	1977	1978	1979
Mean Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.0028}{0.11}$	$\frac{0.00040}{0.014}$	$\frac{0.0020}{0.069}$	$\frac{0.0015}{0.052}$	$\frac{0.0021}{0.075}$
Maximum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.42}{15}$	$\frac{0.017}{0.61}$	$\frac{0.20}{7.0}$	$\frac{0.31}{11}$	$\frac{0.23}{8.0}$
Maximum Instantaneous Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{13.4}{473}$	$\frac{0.11}{3.8}$	$\frac{4.84}{171}$	$\frac{4.84}{171}$	$\frac{13.2}{467}$
Minimum Daily Discharge	$\frac{\text{cms}}{\text{cfs}}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$
Total Annual Runoff	$\frac{\text{ha-m}}{\text{acre-ft}}$	$\frac{10}{83}$	$\frac{1.2}{10}$	$\frac{6.2}{50}$	$\frac{4.6}{37}$	$\frac{6.7}{54}$

(a) Incomplete record for year.

The total annual suspended sediment load for the White River near the Colorado-Utah state line (station 09306395) during the 1978 water year was 1,415,067 tons. Almost 30 percent (412,000 tons) of this total annual load occurred on September 8 during a flash flood. About 50 percent (735,080 tons) of the total annual load occurred in May and June during the peak flow period. There are no data available at this time for the annual suspended sediment load at the White River stations near Tracts Ua and Ub during water years 1975, 1976, 1977, and 1979.

The average salt (dissolved solids) load of the White River at station 09306500 is estimated to be 876 tons per day or 320,000 tons per year (Ref. 2-10).

Table 2.3-6 summarizes the chemical quality data for station 09306500 for samples collected during water years 1975 through 1979. This station is representative of all of the White River stations near Tracts Ua and Ub. In general, White River water can be regarded as very hard and somewhat alkaline. No trace elements have been found at unusually high levels, except for phenols. The maximum value of phenols shown in Table 2.3-6 (11 ug/l) is slightly greater than the Class 3C standard applicable to the White River (10 ug/l). Pesticides and herbicides were below detection limits. Total coliforms at all of the White River stations ranged from 0/100 ml to 760/100 ml with an arithmetic mean value of 103/100 ml, while fecal coliforms ranged from 0/100 ml to 1,395/100 ml with an arithmetic mean value of 87/100 ml. Coliform samples were collected only during the 1975 and 1976 water years. Dissolved oxygen concentrations have usually been near saturation and above 6 mg/l.

The Utah State Department of Social Services, Division of Health, has classified the White River and its tributaries from the confluence with the Green River to the Colorado-Utah state line for the following beneficial uses: 1) protected for nongame fish and other aquatic life, including necessary aquatic organisms in their food chain (Class 3C); 2) protected for agricultural uses including irrigation of crops and stock watering (Class 4).

Table 2.3-6

SUMMARY OF WATER QUALITY OF THE WHITE RIVER,
OCTOBER 1974-SEPTEMBER 1979 (a)
(Station 09306500)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	67	181	32.0	250	107
	Dissolved Solids	66	491	128	913	213
	Total Hardness as CaCO ₃	67	270	54.1	440	140
	Noncarbonate Hardness as CaCO ₃	66	89.5	29.1	190	30
	Oil and Grease	29	1.55	1.96	6	0
	pH	56	8.14	0.374	8.8	7.2
	Specific Conductance at 25°C	76	751	183	1,290	290
	Streamflow, Instantaneous	127	649	728	3,980	42
	Temperature	122	10.3	8.73	26.0	0.0
	Turbidity	36	170	246	1,000	5
	Color	29	11.4	10.7	40	3
MAJOR CATIONS	Calcium, dissolved	67	60.3	11.8	94	35
	Magnesium, dissolved	67	25.4	6.64	49	12
	Potassium, dissolved	67	2.25	0.705	5.4	1.0
	Sodium, dissolved	67	64.7	24.4	150	17
	Sodium Adsorption Ratio	67	1.68	0.504	3.1	0.6
	Percent Sodium	67	33.1	4.87	43	21
	Strontium, dissolved	24	815	281	1,200	60
MAJOR ANIONS	Bicarbonate	60	223	36.7	300	131
	Carbonate	54	0.630	1.89	9	0
	Chloride, dissolved	67	35.6	13.9	89	7.5
	Sulfate, dissolved	67	173	50.4	300	59
	Sulfide as S, dissolved	31	0.148	0.361	1.9	0.0
	Sulfide as S, total	3	0.100	0.100	0.2	0.0
	Fluoride, dissolved	67	0.273	0.0687	0.4	0.1
	Bromide, dissolved	34	0.100	0.0551	0.3	0.0
BIOCHEMICAL CONSTITUENTS	Carbon Dioxide	46	3.21	3.53	20	0.6
	Dissolved Oxygen	47	9.01	1.95	15.0	6.4
	Chemical Oxygen Demand, Low Level	9	33.6	23.4	90	15
	Chemical Oxygen Demand, High Level	28	16.3	18.0	81	0
	Organic Carbon, Dissolved	11	5.57	2.35	9.9	2.9
	Organic Carbon, Suspended	6	1.57	1.23	3.7	0.2
	Organic Carbon, Total	6	7.02	5.06	14	3.1
	Inorganic Carbon, Total	7	48	6.06	50	40
	Chlorophyll A, Periphyton, Spec.	2	3.88	5.20	7.56	0.200
	Chlorophyll B, Periphyton, Spec.	2	0.000	0.000	0.000	0.000
	Chlorophyll A, Periphyton, Chron.-Spec.	3	1.24	1.28	2.61	0.019
	Chlorophyll B, Periphyton, Chron.-Spec.	3	0.267	0.259	0.545	0.07
	Chlorophyll A, Phytoplankton, Spec.	17	2.49	3.27	13.5	0.000
	Chlorophyll B, Phytoplankton, Spec.	17	1.07	1.82	7.35	0.000
	Chlorophyll A, Phytoplankton, Chron.-Fluor.	3	0.184	0.319	0.572	0.000
	Chlorophyll B, Phytoplankton, Chron.-Fluor.	3	0.0213	0.0370	0.064	0.000

Table 2.3-6 (Continued)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
MACRO NUTRIENTS	Ammonia as N, dissolved (mg/l)	41	0.0298	0.0405	0.19	0.00
	Nitrite as N, dissolved (mg/l)	41	0.00315	0.00468	0.01	0.00
	Nitrate as N, dissolved (mg/l)	41	0.103	0.112	0.39	0.00
	Nitrite plus Nitrate as N, dissolved (mg/l)	63	0.217	0.559	4.3	0.00
	Ammonia plus Organic Nitrogen as N, total (mg/l)	42	0.669	0.696	3.3	0.10
	Ortho-Phosphorus as P, dissolved (mg/l)	60	0.0173	0.0246	0.17	0.00
MICRO NUTRIENTS	Phosphorus as P, total (mg/l)	42	0.165	0.230	1.1	0.00
	Boron, dissolved (ug/l)	55	73.1	26.5	150	30
	Copper, dissolved (ug/l)	23	2.65	2.21	8	0
	Iron, dissolved (ug/l)	34	39.4	54.8	270	0
	Manganese, dissolved (ug/l)	34	4.97	7.79	30	0
	Zinc, dissolved (ug/l)	22	14.0	23.0	110	0
TRACE METALS	Molybdenum, dissolved (ug/l)	22	2.14	1.17	4	0
	Cobalt, dissolved (ug/l)	17	< 2.14	-	< 11	0
	Silica as SiO ₂ , dissolved (mg/l)	67	12.9	2.20	18	6.6
	Aluminum, dissolved (ug/l)	31	20.0	22.9	120	0
	Barium, dissolved (ug/l)	22	63.5	109	500	0
	Beryllium, dissolved (ug/l)	8	< 4.00	-	10	0
	Bismuth, dissolved (ug/l)	8	< 9.00	-	< 17	< 2
	Cadmium, dissolved (ug/l)	22	< 0.136	-	1	0
	Chromium, dissolved (ug/l)	22	< 3.14	-	10	0
	Gallium, dissolved (ug/l)	8	< 3.75	-	< 6	0
	Germanium, dissolved (ug/l)	8	< 10.7	-	< 20	< 2
	Lead, dissolved (ug/l)	22	0.636	1.22	5	0
TRACE NON-METALS	Lithium, dissolved (ug/l)	26	< 12.6	-	30	0
	Mercury, dissolved (ug/l)	22	0.0318	0.078	0.3	0.0
	Nickel, dissolved (ug/l)	17	< 3.47	-	12	0
	Selenium, dissolved (ug/l)	22	1.14	0.710	3	0
	Silver, dissolved (ug/l)	8	< 0.625	-	< 2	0
	Tin, dissolved (ug/l)	8	< 9.00	-	< 17	< 2
	Titanium, dissolved (ug/l)	8	< 5.37	-	6	< 2
	Vanadium, dissolved (ug/l)	22	1.65	0.946	4.2	0.0
	Zirconium, dissolved (ug/l)	8	< 15.5	-	< 30	< 3
	Arsenic, dissolved (ug/l)	26	1.12	1.03	4	0
	Cyanide, total (mg/l)	21	0.000476	0.00218	0.01	0.00
	Methylene Blue Active Substances (ug/l)	9	0.022	0.041	0.10	0.00
RADIOACTIVE CONSTITUENTS	Phenols (ug/l)	37	3.43	2.41	11	0
	Pesticides and Herbicides (ug/l)	3	0.00	0.00	0.00	0.00
	Gross Alpha as U-nat., dissolved (ug/l)	22	< 10.9	-	35	< 4.3
	Gross Alpha as U-nat., suspended total (ug/l)	5	9.16	5.86	17	1.5
	Gross Beta as Sr 90/Y 90, dissolved (PC/l)	22	< 3.62	-	9.9	< 1.3
	Gross Beta as Sr 90/Y 90, suspended total (PC/l)	5	4.72	3.67	10	1.0
	Gross Beta as Cs 137, dissolved (PC/l)	22	< 4.23	-	12	< 1.5
	Gross Beta as Cs 137, suspended total (PC/l)	5	5.36	4.03	11	1.0
	Cesium 137, dissolved (PC/l)	4	< 1.00	-	< 1.0	< 1.0
	Radium 226, dissolved (PC/l)	1	0.150	-	0.15	0.15
	Uranium, dissolved, dir. fluor. (PC/l)	1	0.200	-	0.2	0.2

(a) The instantaneous streamflow values shown in this table represent the streamflow at this station at the time that a sample was collected.

The Utah numerical water quality standards for these two beneficial uses of the White River segment are shown in Tables 2.3-7 and 2.3-8. Also, the Utah narrative water quality standards apply to the White River and its tributaries.

In the Uinta Basin Areawide Water Quality Management Plan, fecal coliforms were defined as the limiting water quality parameter for the White River. The apparent cause of the high levels of fecal coliforms was attributed to grazing in the upstream drainage in Colorado (Ref. 2-10).

Evacuation Creek. The water quality of Evacuation Creek is quite different from that of the White River. Table 2.3-9 summarizes the water quality data collected during the water years 1975-1979 at station 09306430 near the mouth of the creek. The concentration of dissolved solids was very high during most of the year (3,000 mg/l to 4,000 mg/l), but decreased during periods of snowmelt or thunderstorm runoff. The concentration of suspended sediment was generally quite low (less than 500 mg/l) during the baseflow period, but increased to very high levels (up to 658,000 mg/l) during runoff from intense thunderstorms and rapid snowmelt.

The salt load of Evacuation Creek at station 09306430 near the mouth is estimated to be 9 tons per day or about 3,000 tons per year (Ref. 2-10). The total annual suspended sediment discharge at this station for water years 1977, 1978, and 1979 averaged 66,900 tons per year. The total annual values for water years 1975 and 1976 are not available, but probably would be similar to the average value mentioned above (based on inspection of the streamflow records for 1975-1979 and the 1975 and 1976 records of instantaneous suspended sediment concentrations).

During water years 1975 and 1976, total coliform levels at the station near the mouth of the creek ranged from 0/100 ml to 1,400/100 ml with an arithmetic mean value of 236/100 ml, while fecal coliform levels ranged from 0/100 ml to 6,620/100 ml with an arithmetic mean value of 523/100 ml. Dissolved oxygen concentrations were lowest during the late summer months

Table 2.3-7

STATE OF UTAH
NUMERICAL STANDARDS FOR PROTECTION OF
BENEFICIAL USES OF WATER

Constituent	Domestic Source		Recreation & Aesthetics		Classified			Aquatic Wildlife		Special Circumstances	Public Use	Coccoloba
	1A	1B	1C	2A	2B	3A	3B	3C	3D			
Bacteriology (No./100 ml)												
30-day Geometric Mean	1	50	5,000	1,000	5,000	•	•	•	•	•	•	•
Maximum Total Coliforms	•	•	2,000	200	2,000	•	•	•	•	•	•	•
Maximum Fecal Coliforms	•	•	•	•	•	•	•	•	•	•	•	•
Physical												
Total Dissolved Solids	•	•	•	•	•	(b)	(b)	•	•	•	•	•
Minimum DO, mg/l (a)	•	•	5.5	5.5	5.5	5.0	5.5	•	•	•	•	•
Maximum Temperature	•	•	•	•	•	20°C	27°C	•	•	•	•	•
Maximum Temp. Change	•	•	•	•	•	2°C	4°C	•	•	•	•	•
pH	5.5-9.0	5.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	5.5-9.0	6.5-9.0	•	•	5.5-9.0	5.5-9.0	•
Turbidity Increase (c)	•	•	•	10 NTU	10 NTU	10 NTU	10 NTU	•	•	15 NTU	•	•
Chemistry (Maximum mg/l)												
Arsenic, dissolved	.05	.05	.05	•	•	•	•	•	•	•	.1	•
Berilium, dissolved	1	1	1	•	•	•	•	•	•	•	•	•
Cadmium, dissolved	.010	.010	.010	•	•	.004 (d)	.004 (d)	•	•	•	.01	•
Chromium, dissolved	.05	.05	.05	•	•	.10	.10	•	•	.10	.10	•
Copper, dissolved	•	•	•	•	•	.01	.01	•	•	•	.2	•
Cyanide	•	•	•	•	•	.005	.005	•	•	•	•	•
Iron, dissolved	•	•	•	•	•	1.0	1.0	•	•	1.0	•	•
Lead, dissolved	.05	.05	.05	•	•	.05	.05	•	•	•	.1	•
Mercury, total	.002	.002	.002	•	•	.0005	.0005	•	•	.0005	•	•
Phenol	•	•	•	•	•	.01	.01	•	•	•	•	•
Selenium, dissolved	.01	.01	.01	•	•	.05	.05	•	•	•	.05	•
Silver, dissolved	.05	.05	.05	•	•	.01	.01	•	•	•	•	•
Zinc, dissolved	•	•	•	•	•	.05	.05	•	•	•	•	•
NH ₃ as N (un-ionized)	•	•	•	•	•	.02	.02	•	•	•	•	•
Chlorine	•	•	•	•	•	.02	.01	•	•	•	•	•
Fluoride, dissolved (e)	1.4-2.4	1.4-2.4	1.4-2.4	•	•	•	•	•	•	•	•	•
NO ₃ as N	10	10	10	•	•	•	•	•	•	•	•	•
Boron, dissolved	•	•	•	•	•	•	•	•	•	•	.75	•
H ₂ S	•	•	•	•	•	.002	.002	•	•	•	•	•
TDS (f)	•	•	•	•	•	•	•	•	•	•	1200	•
Radioactivity (Maximum dCi/l)												
Gross Alpha	15	15	15	•	•	15 (g)	15 (g)	•	•	15 (g)	15 (g)	•
Radium 226, 228 combined	5	5	5	•	•	•	•	•	•	•	•	•
Strontium 90	8	8	8	•	•	•	•	•	•	•	•	•
Tritium	20,000	20,000	20,000	•	•	•	•	•	•	•	•	•
Pesticides (Maximum ug/l)												
Endrin	.2	.2	.2	•	•	.004	.004	•	•	.004	•	•
Lindane	.4	.4	.4	•	•	.01	.01	•	•	.01	•	•
Permethrin	100	100	100	•	•	.01	.01	•	•	.01	•	•
Toxaphene	5	5	5	•	•	.005	.005	•	•	.005	•	•
2, 4-D	100	100	100	•	•	•	•	•	•	•	•	•
2, 4, 5-TP	10	10	10	•	•	•	•	•	•	•	•	•
Pollution Indicators (a)												
Gross Beta (bCi/l)	50	50	50	•	•	50	50	•	•	50	50	•
222 Rn (mg/l)	•	•	5	5	5	5	5	•	•	5	5	•
NO ₃ as N (mg/l)	•	•	•	4	4	4	4	•	•	•	•	•
PO ₄ as P (mg/l) (h)	•	•	•	15	15	15	15	•	•	•	•	•

STANDARDS WILL BE DETERMINED ON A CASE BY CASE BASIS

STANDARDS WILL BE DETERMINED ON A CASE BY CASE BASIS

STANDARDS WILL BE DETERMINED ON A CASE BY CASE BASIS

* Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

(e) Maximum concentration varies according to the daily maximum mean air temperature

Temp	Or	mg/l
12.0 and below		2.4
12.1 to 14.5		2.2
14.6 to 17.0		2.0
17.1 to 21.4		1.8
21.5 to 25.2		1.6
25.3 to 32.5		1.4

(a) These limits are not applicable to lower water levels in deep impoundments.

(b) Not to exceed 100% of saturation

(c) For Classes 2A, 2B, 3A, and 3B at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric values listed. For Class 3D at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric value listed. Short term variances may be considered on a case-by-case basis.

(d) Total dissolved solids (TDS) limit may be adjusted on a case-by-case basis.

(g) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

(h) Limit shall be increased threefold if CaCO₃ hardness in water exceeds 150 mg/l.

(i) PO₄ as P mg/l limit for lakes and reservoirs shall be 0.5.

Source: State of Utah, Department of Social Services, Division of Health, 1975.

Table 2.3-8

STATE OF UTAH
NUMERICAL STANDARDS FOR PROTECTION OF CLASS 3C WATER USE
(Applicable to the White River and Tributaries from the
Confluence with Green River to the State Line)

Parameter	Standard
Physical	
Minimum D.O. (mg/l)	5
Maximum Temperature	27C
Maximum Temperature Change ^(c)	4C
pH	6.5-9.0
Turbidity Increase (NTU)	15 ^(a)
Chemical (Maximum mg/l)	
Cadmium, dissolved	0.004
Chromium, dissolved	0.1
Copper, dissolved	0.01
Cyanide	0.005
Iron, dissolved	1.0
Lead, dissolved	0.05
Mercury, total	0.0005
Phenol	0.01
Selenium, dissolved	0.05
Silver, dissolved	0.01
Zinc, dissolved	0.05
Chlorine	0.2
H ₂ S	0.02
Radiological (Maximum pCi/l)	
Gross Alpha	15
Gross Beta	30
Pesticides (Maximum mg/l)	
Endrin	0.004
Lindane	0.01
Methoxychlor	0.03
Toxaphene	0.005
Pollution Indicators ^(b)	
BOD (mg/l)	5.0
NO ₃ as N (mg/l)	4.0

- (a) At background levels of 150 NTUs or greater, a 10 percent increase limit will be used instead of the numeric values. Short-term variances may be considered on a case-by-case basis.
- (b) Investigations should be conducted to develop more information on where these pollution indicator levels are exceeded.
- (c) This term is not specifically defined within the regulations. It is assumed that this standard implies that it is unlawful for any person to discharge any substances in such a manner to change the ambient water temperature of the White River or its tributaries at any time by more than 4 degrees.

Source: State of Utah, Department of Social Services, Division of Health, 1978.

Table 2.3-9

SUMMARY OF WATER QUALITY OF EVACUATION CREEK,
OCTOBER 1974-SEPTEMBER 1979(a)
(Station 09306430)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	51	371	82.0	450	98
	Dissolved Solids	51	3,290	770	4,710	793
	Total Hardness as CaCO ₃	51	1,040	220	1,200	250
	Noncarbonate Hardness as CaCO ₃	51	657	157	920	130
	Oil and Grease	29	10.1	46.2	250	0
	pH	63	7.93	0.365	9.0	7.3
	Specific Conductance at 25°C	78	4,100	1,000	5,800	1,200
	Streamflow, Instantaneous	129	8.17	46.1	460	0.01
	Temperature	127	14.3	9.44	33.5	0.0
	Turbidity	39	1,100	5,280	33,000	0
	Color	30	9.77	8.27	50	3
MAJOR CATIONS	Calcium, dissolved	51	162	31.7	240	60
	Magnesium, dissolved	51	150	39.6	210	24
	Potassium, dissolved	51	8.26	1.77	11	1.8
	Sodium, dissolved	51	677	171	990	160
	Sodium Adsorption Ratio	51	9.08	1.62	12	4.3
	Percent Sodium	51	50.5	3.43	63	42
	Strontium, dissolved	21	3,790	327	4,300	3,000
MAJOR ANIONS	Bicarbonate	48	449	102	550	120
	Carbonate	39	0.00	0.00	0	0
	Chloride, dissolved	51	46.2	16.6	83	6.1
	Sulfate, dissolved	51	2,010	495	3,000	430
	Sulfide as S, dissolved	32	0.187	0.417	2.0	0.0
	Sulfide as S, total	4	0.200	0.400	0.8	0.0
	Fluoride, dissolved	51	0.823	0.247	2.3	0.5
	Bromide, dissolved	36	0.308	0.113	0.6	0.1
BIOCHEMICAL CONSTITUENTS	Carbon Dioxide	37	10.8	8.79	35	0.7
	Dissolved Oxygen	46	7.77	1.56	11.0	4.8
	Chemical Oxygen Demand, Low Level	8	38.1	12.9	60	23
	Chemical Oxygen Demand, High Level	32	114	454	2,600	6
	Organic Carbon, Dissolved	12	14.4	7.76	35	6.2
	Organic Carbon, Suspended	5	0.480	0.148	0.7	0.3
	Organic Carbon, Total	7	11.0	3.17	15	7.7
	Inorganic Carbon, Total	5	100	9.96	110	86
	Chlorophyll A, Periphyton, Spec.	2	0.850	1.20	1.70	0.000
	Chlorophyll B, Periphyton, Spec.	2	0.0500	0.0707	0.100	0.000
	Chlorophyll A, Periphyton, Chrom.-Spec.	1	0.692	-	0.692	0.692
	Chlorophyll B, Periphyton, Chrom.-Spec.	1	0.0940	-	0.094	0.094
	Chlorophyll A, Phytoplankton, Spec.	18	3.36	4.92	18.0	0.000
	Chlorophyll B, Phytoplankton, Spec.	18	1.76	2.68	10.0	0.000
	Chlorophyll A, Phytoplankton, Chrom.-Fluor.	3	1.48	2.26	4.42	0.000
	Chlorophyll B, Phytoplankton, Chrom.-Fluor.	3	0.0213	0.0370	0.064	0.000

Table 2.3-9 (Continued)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
MACRO-NUTRIENTS	Ammonia as N, dissolved (mg/l)	44	0.0316	0.0342	0.12	0.00
	Nitrite as N, dissolved (mg/l)	43	0.0168	0.0233	0.11	0.00
	Nitrate as N, dissolved (mg/l)	42	0.596	0.601	1.8	0.00
	Nitrite plus Nitrate as N, dissolved (mg/l)	48	0.610	0.688	2.9	0.00
	Ammonia plus Organic Nitrogen as N, total (mg/l)	45	1.59	4.42	30	0.16
	Ortho-Phosphorus as P, dissolved (mg/l)	48	0.0104	0.0105	0.04	0.00
MICRO-NUTRIENTS	Phosphorus as P, total (mg/l)	45	0.821	4.91	33	0.00
	Boron, dissolved (ug/l)	39	1.630	742	2,600	10
	Copper, dissolved (ug/l)	26	33.8	120	600	0
	Iron, dissolved (ug/l)	38	56.6	62.1	470	0
	Manganese, dissolved (ug/l)	38	103	79.8	320	10
	Zinc, dissolved (ug/l)	25	26.8	24.3	110	0
TRACE METALS	Molybdenum, dissolved (ug/l)	24	40.1	13.8	76	0
	Cobalt, dissolved (ug/l)	19	< 5.79	-	< 60	0
	Silica as SiO ₂ , dissolved (mg/l)	51	9.69	1.81	14	6.1
	Aluminum, dissolved (ug/l)	34	20.0	26.7	110	0
	Barium, dissolved (ug/l)	24	59.2	77.0	300	0
	Beryllium, dissolved (ug/l)	8	< 6.25	-	10	0
	Bismuth, dissolved (ug/l)	5	< 54.2	-	< 90	< 6
	Cadmium, dissolved (ug/l)	25	0.0800	0.277	1	0
	Chromium, dissolved (ug/l)	25	6.20	8.57	30	0
	Gallium, dissolved (ug/l)	5	< 22.6	-	< 30	< 3
	Germanium, dissolved (ug/l)	5	< 61.0	-	< 130	< 10
	Lead, dissolved (ug/l)	25	1.16	1.21	4	0
	Lithium, dissolved (ug/l)	28	114	36.7	170	10
	Mercury, dissolved (ug/l)	25	0.0320	0.0690	0.2	0
TRACE NON-METALS	Nickel, dissolved (ug/l)	19	4.84	2.52	9	0
	Selenium, dissolved (ug/l)	25	1.60	1.53	5	0
	Silver, dissolved (ug/l)	8	< 1.50	-	< 6	0
	Tin, dissolved (ug/l)	5	< 56.2	-	< 100	< 6
	Titanium, dissolved (ug/l)	5	< 25.8	-	< 45	< 4
	Vanadium, dissolved (ug/l)	24	0.912	0.966	3.2	0.0
	Zirconium, dissolved (ug/l)	5	< 90.0	-	< 130	< 10
	Arsenic, dissolved (ug/l)	29	1.52	1.18	6	0
	Cyanide, total (mg/l)	23	0.000870	0.00288	0.01	0.00
	Methylene Blue Active Substances (ug/l)	8	0.0500	0.0534	0.10	0.00
RADIOACTIVE CONSTITUENTS	Phenols (ug/l)	40	3.32	4.27	25	0
	Pesticides and Herbicides (ug/l)	3	0.00	0.00	0.00	0.00
	Gross Alpha as U-nat., dissolved (ug/l)	22	< 65.9	-	280	< 22
	Gross Alpha as U-nat., suspended total (ug/l)	4	< 0.450	-	0.6	< 0.4
	Gross Beta as Sr 90/Y 90, dissolved (PC/l)	24	< 22.4	-	53	< 7.5
	Gross Beta as Sr 90/Y 90, suspended total (PC/l)	4	1.72	1.32	3.6	0.5
	Gross Beta as Cs 137, dissolved (PC/l)	22	< 26.8	-	66	< 9.5
	Gross Beta as Cs 137, suspended total (PC/l)	4	1.82	1.57	4.1	0.5
	Cesium 137, dissolved (PC/l)	3	< 1.00	-	< 1.0	< 1.0
	Radium 226, dissolved (PC/l)	0	-	-	-	-
	Uranium, dissolved, dir. fluor. (PC/l)	0	-	-	-	-

(a) The instantaneous streamflow values shown in this table represent the streamflow at this station at the time that a sample was collected.

when the water temperatures were greatest, but were above 6 mg/l most of the time. Pesticides and herbicides were not detected in any samples. Certain of the trace materials were present at relatively high levels in some of the samples.

The beneficial uses of Evacuation Creek would be classified the same as for the White River (i.e., Classes 3C and 4) since it is a tributary. The concentrations of some constituents at the station near the mouth during water years 1975-1979 have at times exceeded the State of Utah numerical water quality standards for these two uses. These constituents include: copper, cyanide, phenols, zinc, boron, dissolved solids, gross alpha, and gross beta. Also, the Class 3C standard for maximum water temperature (27C) has frequently been exceeded during the late summer months, and dissolved oxygen concentrations have at times been less than the state's Class 3C minimum standard (5 mg/l).

Southam Canyon, Asphalt Wash, and Hells Hole Canyon. Flow events in these drainages are very irregular and of short duration. Water quality analyses have shown a great deal of variation between flow events and between drainages. The water quality data collected during water years 1975-1979 at the stations at or near the mouths of these three dry washes are summarized in Tables 2.3-10, 2.3-11, and 2.3-12.

2.3.2 SYSTEM INTERACTIONS

There are four interacting water systems within the study area:

- White River
- Bird's Nest Aquifer
- Evacuation Creek
- Ephemeral tributaries

The flow of the White River changes very little across the study area, such that flow gains and water quality changes caused by groundwater or surface

Table 2.3-10

SUMMARY OF WATER QUALITY OF SOUTHAM CANYON,
OCTOBER 1974-SEPTEMBER 1979(a)
(Station 09306610)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	4	164	30.7	189	119
	Dissolved Solids	4	579	315	999	262
	Total Hardness as CaCO ₃	4	147	68.2	220	84
	Non-carbonate Hardness as CaCO ₃	4	13.5	15.9	31	0
	Oil and Grease	1	0.00	-	0	0
	pH	3	8.00	0.100	8.1	7.9
	Specific Conductance at 25°C (unhos/cm)	4	789	492	1,480	330
	Streamflow, Instantaneous (cfs)	6	1.47	1.69	4.70	0.2
	Temperature (°C)	6	5.56	6.94	17.0	0.0
	Turbidity (JTU)	1	1,000	-	1,000	1,000
	Color (PCU)	1	300	-	300	300
MAJOR CATIONS	Calcium, dissolved	4	52.0	25.7	79	29
	Magnesium, dissolved	4	4.40	1.43	6.2	2.8
	Potassium, dissolved	4	3.20	0.812	4.0	2.5
	Sodium, dissolved	4	128	87.2	250	50
	Sodium Adsorption Ratio	4	4.40	2.07	7.3	2.4
	Percent Sodium	4	62.8	6.40	70	56
	Strontium, dissolved	3	1,027	310	1,300	680
MAJOR ANIONS	Bicarbonate	3	197	45.4	290	145
	Carbonate	2	0.00	0.00	0	0
	Chloride, dissolved	4	12.8	11.0	28	2.8
	Sulfate, dissolved	4	261	184	500	55
	Sulfide as S, dissolved	1	0.00	-	0.0	0.0
	Sulfide as S, total	1	0.00	-	0.0	0.0
	Fluoride, dissolved	4	0.525	0.294	0.9	0.2
	Branide, dissolved	2	0.0500	0.0707	0.1	0.0
	Carbon Dioxide	2	3.65	1.34	4.60	2.7
	Dissolved Oxygen	1	11.5	-	11.5	11.5
BIOCHEMICAL CONSTITUENTS	Chemical Oxygen Demand, Low Level	0	-	-	-	-
	Chemical Oxygen Demand, High Level	2	531	649	990	72
	Organic Carbon, Dissolved	2	8.50	4.95	12	5.0
	Organic Carbon, Suspended	0	-	-	-	-
	Organic Carbon, Total	0	-	-	-	-
	Inorganic Carbon, Total	0	-	-	-	-
	Chlorophyll A, Periphyton, Spec.	1	45.0	-	45	45
	Chlorophyll B, Periphyton, Spec.	0	-	-	-	-
	Chlorophyll A, Periphyton, Spec.	0	-	-	-	-
	Chlorophyll B, Periphyton, Spec.	0	-	-	-	-
	Chlorophyll A, Phytoplankton, Spec.	0	-	-	-	-
	Chlorophyll B, Phytoplankton, Spec.	0	-	-	-	-
	Chlorophyll A, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-
	Chlorophyll B, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-

Table 2.3-10 (Continued)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
MACRO NUTRIENTS	Ammonia as N, dissolved (mg/l)	2	0.070	0.000	0.07	0.07
	Nitrite as N, dissolved (mg/l)	1	0.030	-	0.03	0.03
	Nitrate as N, dissolved (mg/l)	1	2.40	-	2.4	2.4
	Nitrite plus Nitrate as N, dissolved (mg/l)	3	1.77	0.551	2.4	1.4
	Ammonia plus Organic Nitrogen as N, total (mg/l)	2	18.4	16.5	30	6.7
	Ortho-Phosphorus as P, dissolved (mg/l)	3	0.0033	0.00577	0.09	0.00
MICRO NUTRIENTS	Phosphorus as P, total (mg/l)	2	7.90	8.63	14	1.8
	Boron, dissolved (ug/l)	4	92.5	15.0	110	80
	Copper, dissolved (ug/l)	2	25.0	21.2	40	10
	Iron, dissolved (ug/l)	4	150	124	290	10
	Manganese, dissolved (ug/l)	4	7.50	5.00	10	0
	Zinc, dissolved (ug/l)	2	45.0	21.2	60	30
TRACE METALS	Molybdenum, dissolved (ug/l)	3	15.7	9.50	25	6
	Cobalt, dissolved (ug/l)	1	< 10.0	-	< 10	< 10
	Silica as SiO ₂ , dissolved (mg/l)	4	10.5	3.83	16	7.3
	Aluminum, dissolved (ug/l)	3	77.0	92.9	180	0
	Barium, dissolved (ug/l)	2	150	70.7	200	100
	Beryllium, dissolved (ug/l)	1	10.0	-	10	10
	Bismuth, dissolved (ug/l)	1	< 8.00	-	< 8	< 8
	Cadmium, dissolved (ug/l)	2	0.00	0.00	0	0
	Chromium, dissolved (ug/l)	2	1.00	1.41	2	0
	Gallium, dissolved (ug/l)	1	< 3.00	-	< 3	< 3
	Germanium, dissolved (ug/l)	1	< 20.0	-	< 20	< 20
	Lead, dissolved (ug/l)	2	0	0	0	0
TRACE NON METALS	Lithium, dissolved (ug/l)	2	15.0	7.07	20	10
	Mercury, dissolved (ug/l)	2	0	0	0	0
	Nickel, dissolved (ug/l)	1	0	-	0	0
	Selenium, dissolved (ug/l)	2	1.50	0.707	2	1
	Silver, dissolved (ug/l)	1	< 1.00	-	< 1	< 1
	Tin, dissolved (ug/l)	1	< 8.00	-	< 8	< 8
	Titanium, dissolved (ug/l)	1	< 5.00	-	< 5	< 5
	Vanadium, dissolved (ug/l)	2	13.0	1.41	14	12
	Zirconium, dissolved (ug/l)	1	< 10.0	-	< 10	< 10
	Arsenic, dissolved (ug/l)	2	6.00	1.41	7	5
	Cyanide, total (mg/l)	1	0.00	-	0.00	0.00
	Methylene Blue Active Substances (mg/l)	2	0.0500	0.0707	0.10	0.00
RADIOACTIVE CONSTITUENTS	Phenols (ug/l)	2	8.00	0.00	8	0
	Pesticides and Herbicides (ug/l)	0	-	-	-	-
	Gross Alpha as U nat., dissolved (ug/l)	1	< 3.60	-	< 3.6	< 3.6
	Gross Alpha as U nat., Suspended total (ug/l)	0	-	-	-	-
	Gross Beta as Sr 90/Y 90, dissolved (pCi/l)	1	6.60	-	6.6	6.6
	Gross Beta as Sr 90/Y 90, Suspended total (pCi/l)	0	-	-	-	-
	Gross Beta as Cs 137, dissolved (pCi/l)	1	8.30	-	8.3	8.3
	Gross Beta as Cs 137, Suspended total (pCi/l)	0	-	-	-	-
	Cesium 137, dissolved (pCi/l)	4	0.170	-	0.17	0.17
	Radium 226, dissolved (pCi/l)	1	1.30	-	1.3	1.3
	Uranium, dissolved, dir. fluor (pCi/l)	1	-	-	-	-

(a) The instantaneous streamflow values shown in this table represent the streamflow at this station at the time that a sample was collected.

Table 2.3-11

SUMMARY OF WATER QUALITY OF ASPIHALT WASIL,
OCTOBER 1974-SEPTEMBER 1979 (a)
(Station 09306625)

PARAMETERS	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
GENERAL CHARACTERISTICS					
Total Alkalinity as CaCO ₃ (mg/l)	4	139	67.6	189	39
Dissolved Solids (mg/l)	4	642	483	1,330	305
Total Hardness as CaCO ₃ (mg/l)	4	144	70.7	230	68
Noncarbonate Hardness as CaCO ₃ (mg/l)	4	50	62.7	130	0
Oil and Grease (mg/l)	1	0.00	-	0	0
pH (units)	2	7.70	0.424	8.0	7.4
Specific Conductance at 25°C (umhos/cm)	3	1,042	763	1,920	418
Streamflow, Instantaneous (cfs)	7	5.45	3.71	8.7	0.10
Temperature (°C)	6	9.33	4.61	11.5	0.0
Turbidity (JTU)	2	1,650	919	2,300	1,060
Color (PCU)	1	300	-	300	300
MAJOR CATIONS					
Calcium, dissolved (mg/l)	4	41.8	24.3	67	19
Magnesium, dissolved (mg/l)	4	9.7	5.0	15	4.9
Potassium, dissolved (mg/l)	4	3.87	1.25	5.5	2.9
Sodium, dissolved (mg/l)	4	160	136	360	67
Sodium Adsorption Ratio	4	5.38	3.17	10	2.8
Percent Sodium	4	66.5	9.33	77	50
Strontium, dissolved (ug/l)	3	1,010	634	1,600	340
MAJOR ANIONS					
Bicarbonate (mg/l)	4	169	82.5	230	47
Carbonate (mg/l)	2	0.00	0.00	0	0
Chloride, dissolved (mg/l)	4	16.4	11.9	34	7.5
Sulfate, dissolved (mg/l)	4	308	327	740	34
Sulfide as S, dissolved (mg/l)	2	0.100	0.141	0.2	0.0
Sulfide as S, total (mg/l)	0	-	-	-	-
Fluoride, dissolved (mg/l)	4	0.475	0.310	0.9	0.2
Bromide, dissolved (mg/l)	1	0.100	-	0.1	0.1
BIOCHEMICAL CONSTITUENTS					
Carbon Dioxide (mg/l)	2	7.60	6.22	12	3.2
Dissolved Oxygen (mg/l)	1	12.0	-	12.0	12.0
Chemical Oxygen Demand, Low Level (mg/l)	0	-	-	-	-
Chemical Oxygen Demand, High Level (mg/l)	1	85.0	-	85	85
Organic Carbon, Dissolved (mg/l)	1	13.0	-	13	13
Organic Carbon, Suspended (mg/l)	0	-	-	-	-
Inorganic Carbon, Total (mg/l)	0	-	-	-	-
Inorganic Carbon, Total (mg/sq. m)	0	-	-	-	-
Chlorophyll A, Periphyton, Spec. (mg/sq. m)	0	-	-	-	-
Chlorophyll B, Periphyton, Spec. (mg/sq. m)	0	-	-	-	-
Chlorophyll A, Periphyton, Chron.-Spec. (mg/sq. m)	0	-	-	-	-
Chlorophyll B, Periphyton, Chron.-Spec. (mg/sq. m)	0	-	-	-	-
Chlorophyll A, Phytoplankton, Spec. (ug/l)	0	-	-	-	-
Chlorophyll B, Phytoplankton, Spec. (ug/l)	0	-	-	-	-
Chlorophyll A, Phytoplankton, Chron.-Fluor. (ug/l)	0	-	-	-	-
Chlorophyll B, Phytoplankton, Chron.-Fluor. (ug/l)	0	-	-	-	-

Table 2.3-11 (Continued)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
MACRO NUTRIENTS	Ammonia as N, dissolved (mg/l)	2	0.0450	0.0636	0.09	0.00
	Nitrite as N, dissolved (mg/l)	2	0.0400	0.0276	0.06	0.02
	Nitrate as N, dissolved (mg/l)	2	2.75	0.919	3.4	2.1
	Nitrite plus Nitrate as N, dissolved (mg/l)	3	2.47	0.907	3.5	1.8
	Ammonia plus Organic Nitrogen as N, total (mg/l)	2	20.7	23.1	37	4.4
	Ortho-Phosphorus as P, dissolved (mg/l)	3	0.0833	0.0379	0.11	0.04
	Phosphorus as P, total (mg/l)	2	23.0	24.1	40	5.9
MICRO- NUTRIENTS	Boron, dissolved (ug/l)	4	202	104	280	50
	Copper, dissolved (ug/l)	2	26.5	26.2	45	8
	Iron, dissolved (ug/l)	4	195	137	360	40
	Manganese, dissolved (ug/l)	3	93.3	144	260	10
	Zinc, dissolved (ug/l)	2	80.0	56.6	120	40
	Molybdenum, dissolved (ug/l)	2	15.5	13.4	25	6
	Cobalt, dissolved (ug/l)	1	< 10.0	-	< 10	< 10
TRACE METALS	Silica as SiO ₂ , dissolved (mg/l)	4	8.30	4.58	14	4.4
	Aluminum, dissolved (ug/l)	3	100	55.7	160	50
	Barium, dissolved (ug/l)	1	200	-	200	200
	Beryllium, dissolved (ug/l)	1	20.0	-	20	20
	Bismuth, dissolved (ug/l)	1	< 10.0	-	< 10	< 10
	Cadmium, dissolved (ug/l)	1	0.00	-	0	0
	Chromium, dissolved (ug/l)	1	0.00	-	0	0
	Gallium, dissolved (ug/l)	1	< 5.00	-	< 5	< 5
	Germanium, dissolved (ug/l)	1	< 20.0	-	< 20	< 20
	Lead, dissolved (ug/l)	1	0.00	-	0	0
	Lithium, dissolved (ug/l)	2	25.0	21.2	40	10
	Mercury, dissolved (ug/l)	2	0.00	-	0.0	0.0
	Nickel, dissolved (ug/l)	1	0.00	-	0	0
	Selenium, dissolved (ug/l)	2	1.50	0.707	2	1
	Silver, dissolved (ug/l)	1	< 1.00	-	< 1	< 1
	Tin, dissolved (ug/l)	1	< 10.0	-	< 10	< 10
	Titanium, dissolved (ug/l)	1	< 7.00	-	< 7	< 7
	Vanadium, dissolved (ug/l)	1	8.30	-	8.3	8.3
	Zirconium, dissolved (ug/l)	1	< 20.0	-	< 20	< 20
TRACE NON METALS	Arsenic, dissolved (ug/l)	2	19.5	24.8	37	2
	Cyanide, total (mg/l)	1	0.0100	-	0.01	0.01
	Methylene Blue Active Substances (mg/l)	1	0.100	-	0.1	0.1
	Phenols (ug/l)	1	1.00	-	1	1
	Pesticides and Herbicides (ug/l)	0	-	-	-	-
RADIOACTIVE CONSTITUENTS	Gross Alpha as U-nat., dissolved (ug/l)	1	< 10.0	-	< 10	< 10
	Gross Alpha as U-nat., suspended total (ug/l)	0	-	-	-	-
	Gross Beta as Sr 90/Y 90, dissolved (pCi/l)	1	21.0	-	21	21
	Gross Beta as Sr 90/Y 90, suspended total (pCi/l)	0	-	-	-	-
	Gross Beta as Cs 137, dissolved (pCi/l)	1	26.0	-	26	26
	Gross Beta as Cs 137, suspended total (pCi/l)	0	-	-	-	-
	Cesium 137, dissolved (pCi/l)	0	-	-	-	-
	Radium 226, dissolved (pCi/l)	1	0.290	-	0.29	0.29
	Uranium, dissolved, dir. fluor. (pCi/l)	1	2.00	-	2.0	2.0

(a) The instantaneous streamflow values shown in this table represent the streamflow at this station at the time that a sample was collected.

Table 2.3-12

SUMMARY OF WATER QUALITY OF HELLS HOLE CANYON
OCTOBER 1974-SEPTEMBER 1979(a)
(Station 09306405)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	4	196	150	410	93
	Dissolved Solids	4	1,250	914	2,410	485
	Total Hardness as CaCO ₃	4	713	514	1,400	290
	Non carbonate Hardness as CaCO ₃	4	530	575	1,300	0
	Oil and Grease	0	-	-	-	-
	pH	1	8.30	-	8.3	8.3
	Specific Conductance at 25°C	4	1,530	976	2,670	710
	Streamflow, Instantaneous	3	19.1	18.6	39	2.3
	Temperature	2	15.0	7.07	20.0	10.0
	Turbidity	2	95.5	134	190	1
	Color	0	-	-	-	-
	Calcium, dissolved	4	224	180	470	64
	Magnesium, dissolved	4	34.3	17.2	57	14
	Potassium, dissolved	4	10.7	5.26	18	6.7
	Sodium, dissolved	4	125	59.6	170	39
MAJOR CATIONS	Sodium Adsorption Ratio	4	2.13	0.854	3.0	1.0
	Percent Sodium	4	29.5	11.1	45	21
	Strontium, dissolved	3	1,760	1,500	3,500	840
	Bicarbonate	3	152	68.1	231	113
	Carbonate	0	-	-	-	-
MAJOR ANIONS	Chloride, dissolved	4	8.23	3.27	12	4.1
	Sulfate, dissolved	4	758	654	1,600	220
	Sulfide as S, dissolved	2	0.200	0.000	0.2	0.2
	Sulfide as S, total	0	-	-	-	-
	Fluoride, dissolved	4	0.500	0.200	0.8	0.4
	Bromide, dissolved	0	-	-	-	-
	Carbon Dioxide	0	-	-	-	-
	Dissolved Oxygen	0	-	-	-	-
BIOCHEMICAL CONSTITUENTS	Chemical Oxygen Demand, Low Level	0	-	-	-	-
	Chemical Oxygen Demand, High Level	0	-	-	-	-
	Organic Carbon, Dissolved	0	-	-	-	-
	Organic Carbon, Suspended	0	-	-	-	-
	Organic Carbon, Total	0	-	-	-	-
	Inorganic Carbon, Total	0	-	-	-	-
	Chlorophyll A, Periphyton, Spec.	0	-	-	-	-
	Chlorophyll B, Periphyton, Spec.	0	-	-	-	-
	Chlorophyll A, Periphyton, Chrom.-Spec.	0	-	-	-	-
	Chlorophyll B, Periphyton, Chrom.-Spec.	0	-	-	-	-
	Chlorophyll A, Phytoplankton, Spec.	0	-	-	-	-
	Chlorophyll B, Phytoplankton, Spec.	0	-	-	-	-
	Chlorophyll A, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-
	Chlorophyll B, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-
	Chlorophyll A, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-
	Chlorophyll B, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-
	Chlorophyll A, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-
	Chlorophyll B, Phytoplankton, Chrom.-Fluor.	0	-	-	-	-

Table 2.3-12 (Continued)

PARAMETERS		Number of Samples	Mean	Standard Deviation	Maximum	Minimum
MACRO-NUTRIENTS	Ammonia as N, dissolved (mg/l)	2	0.00	0.00	0.00	0.00
	Nitrite as N, dissolved (mg/l)	2	0.165	0.0636	0.21	0.12
	Nitrate as N, dissolved (mg/l)	2	1.04	0.375	1.3	0.77
	Nitrate plus Nitrate as N, dissolved (mg/l)	3	0.810	0.733	1.5	0.04
	Ammonia plus Organic Nitrogen as N, total (mg/l)	2	1.35	0.212	1.5	1.2
	Ortho-Phosphorus as P, dissolved (mg/l)	3	0.00	0.00	0.00	0.00
	Phosphorus as P, total (mg/l)	2	0.0500	0.0283	0.07	0.03
MICRO-NUTRIENTS	Boron, dissolved (ug/l)	4	248	123	360	90
	Copper, dissolved (ug/l)	2	22.0	7.07	27	17
	Iron, dissolved (ug/l)	4	133	193	420	10
	Manganese, dissolved (ug/l)	2	265	361	520	10
	Zinc, dissolved (ug/l)	2	120	14.1	130	110
	Molybdenum, dissolved (ug/l)	1	30.0	-	30	30
	Cobalt, dissolved (ug/l)	0	-	-	-	-
TRACE METALS	Silica as SiO ₂ , dissolved (mg/l)	4	10.9	4.24	15	6.4
	Aluminum, dissolved (ug/l)	3	13.3	23.1	40	0
	Barium, dissolved (ug/l)	0	-	-	-	-
	Beryllium, dissolved (ug/l)	0	-	-	-	-
	Bismuth, dissolved (ug/l)	0	-	-	-	-
	Cadmium, dissolved (ug/l)	0	-	-	-	-
	Chromium, dissolved (ug/l)	0	-	-	-	-
TRACE NON-METALS	Gallium, dissolved (ug/l)	0	-	-	-	-
	Germanium, dissolved (ug/l)	0	-	-	-	-
	Lead, dissolved (ug/l)	0	-	-	-	-
	Lithium, dissolved (ug/l)	2	35.0	35.4	60	10
	Mercury, dissolved (ug/l)	2	0.00	0.00	0.0	0.0
	Nickel, dissolved (ug/l)	0	-	-	-	-
	Selenium, dissolved (ug/l)	2	1.00	1.41	2	0
	Silver, dissolved (ug/l)	0	-	-	-	-
	Tin, dissolved (ug/l)	0	-	-	-	-
	Titanium, dissolved (ug/l)	0	-	-	-	-
	Vanadium, dissolved (ug/l)	0	-	-	-	-
	Zirconium, dissolved (ug/l)	0	-	-	-	-
	Arsenic, dissolved (ug/l)	2	1.50	0.767	2	1
	Cyanide, total (mg/l)	0	-	-	-	-
TRACE RADIOACTIVE CONSTITUENTS	Methylene Blue Active Substances (ug/l)	0	-	-	-	-
	Phenols (ug/l)	0	-	-	-	-
	Pesticides and Herbicides (ug/l)	0	-	-	-	-
	Gross Alpha as U-nat., dissolved (ug/l)	0	-	-	-	-
TRACE RADIOACTIVE CONSTITUENTS	Gross Alpha as U-nat., suspended total (ug/l)	0	-	-	-	-
	Gross Beta as Sr 90/Y 90, dissolved (pCi/l)	0	-	-	-	-
	Gross Beta as Sr 90/Y 90, suspended total (pCi/l)	0	-	-	-	-
	Gross Beta as Cs 137, dissolved (pCi/l)	0	-	-	-	-
	Gross Beta as Cs 137, suspended total (pCi/l)	0	-	-	-	-
	Cesium 137, dissolved (pCi/l)	0	-	-	-	-
TRACE RADIOACTIVE CONSTITUENTS	Radium 226, dissolved (pCi/l)	0	-	-	-	-
	Uranium, dissolved, dir. floor, (pCi/l)	0	-	-	-	-

(a) The instantaneous streamflow values shown in this table represent the streamflow at this station at the time that a sample was collected.

water inflow are difficult to discern. Evacuation Creek, the only consistent surface flow into the White River in the vicinity of the tracts, averages less than 1 cfs near its mouth during the baselow period. During this period, the flow of the creek is supplied almost completely by groundwater seepage from the Bird's Nest Aquifer below Watson.

2.3.3 GROUNDWATER

2.3.3.1 Groundwater Occurrence

Groundwater occurs throughout the region in alluvial deposits along major stream courses, and within portions of the Uinta, Green River, Wasatch, and Mesa Verde Formations (Ref. 2-11). The Green River Formation, and especially its uppermost member, the Parachute Creek Member, contains the principal oil shale zone. Most of the deeper drilling on the tracts was done to investigate this zone.

Significant runoff from the ephemeral tract drainages and Evacuation Creek occasionally occurs during the low flow (base flow) periods of the White River. These runoff events (flash floods) cause short-term changes to the flow rate and water quality of the White River. The most significant effects are normally related to the sediment loads discharged to the White River during such occurrences.

2.3.2.2 Aquifers

A typical geophysical log representative of the region indicates the potential water-bearing zones (Figure 2.3-4). The Bird's Nest Aquifer is the principal aquifer investigated during the baseline study for this project. This aquifer has been previously described by Cashion and Brown (Ref. 2-12). The Bird's Nest Aquifer is located near the top of the Parachute Creek Member of the Green River Formation and consists predominantly of cavities formed by the leaching of nahcolite from the marlstone strata. The aquifer is very persistent laterally and vertically throughout the area investigated, as indicated by geophysical logs of project wells and oil and gas wells. The thickness of the aquifer ranges from 90 to about 205 feet and averages

about 115 feet. The lateral persistence of the aquifer is shown in Figure 2.3-5. The upper surface of the aquifer slopes to the northwest uniformly at approximately 250 feet per mile. The stratigraphic position of the aquifer is very consistent. The aquifer typically occurs in the top 50 to 125 feet of the Green River Formation and is at an average of 430 feet above the Mahogany Marker.

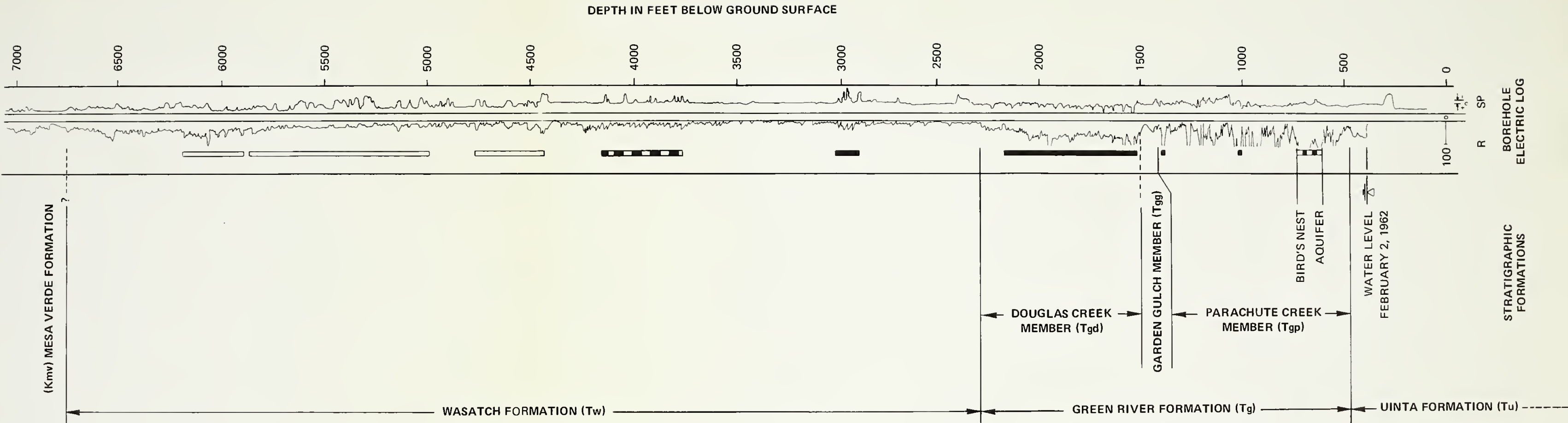
On electric logs, the geophysical appearance of the aquifer is uniform throughout the area investigated and consists of two zones of high resistivity separated by an interval of low resistivity. The low-resistivity zone commonly occurs in the upper third of the aquifer and is usually 15 to 20 feet thick. The upper high-resistivity zone is a sandstone believed to be correlative to the Horse Bench Sandstone of Cashion (Ref. 2-6); the lower high resistivity zone is attributed to solution cavities and fracturing.

The Bird's Nest Aquifer is exposed continuously at the confluence of the White River and Evacuation Creek and then southward for several miles along the banks or canyon walls of Evacuation Creek. Springs and seepage from the aquifer are common throughout the area.

Geophysical logs of oil and gas wells in the area and holes drilled as part of the baseline investigation (notably G-16A and P-4) indicate that the Douglas Creek Member of the Green River Formation contains several hundred feet of water-bearing material. One project well (G-16A) located south of the tracts in the southeast quarter of Section 21 (T11S, R25E) had a flow of about 2 gpm from a depth of 165 feet. The locations of the project wells which have been used to monitor the bedrock aquifers are shown in Figure 2.3-6.

An aquifer of limited areal extent within a zone near the contact of the Uinta and Green River Formations was encountered at the P-2 location near the north border of Tract Ua. This aquifer is referred to as the Upper Aquifer. It was not encountered at any other location during drilling activities for the baseline investigation.

T.D. 7033 FT.



LEGEND

ELECTRIC LOG OF BOREHOLE 13
SHOWING AQUIFER ZONES
(C, NE, SW, SEC.32, T10S, R24E)

SP R

SP - SPONTANEOUS POTENTIAL
R - RESISTIVITY

POTENTIAL AQUIFER ZONE BASED UPON
ELECTRIC LOG RESPONSE.
OPEN WHERE WATER QUALITY INDICATED
TO BE SLIGHTLY SALINE TO SALINE.

Figure 2.3-4 TYPICAL BOREHOLE ELECTRIC LOG
OF ROCK FORMATIONS BENEATH SITE

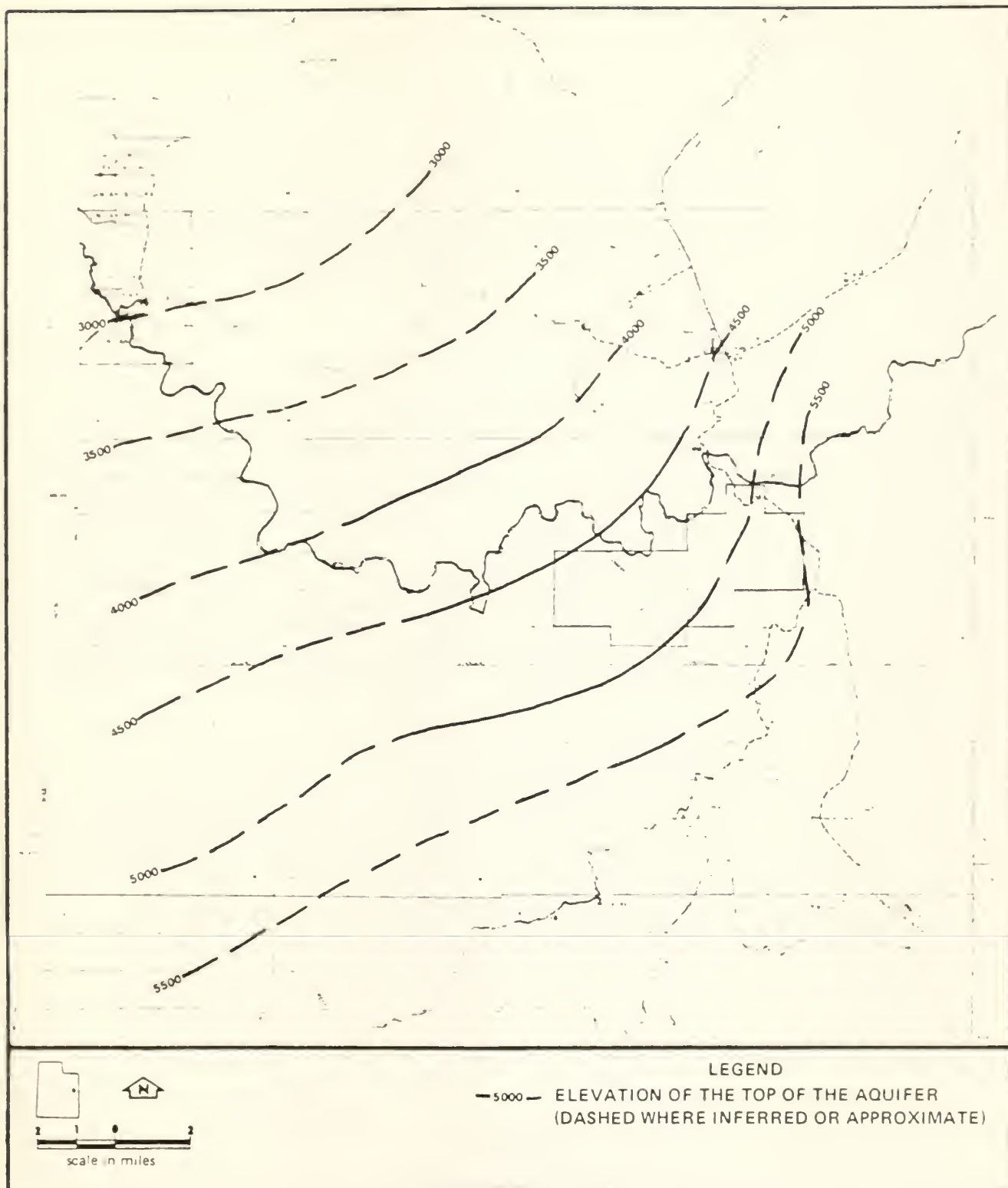


Figure 2.3-5 STRUCTURAL CONTOURS ON TOP OF BIRD'S NEST AQUIFER, S.E. UINTA BASIN

Investigation of the alluvial channel materials on and adjacent to the tracts has been sufficient to describe the presence or absence of water. Southam Canyon, the principal area of interest (owing to potential processed shale deposition), has been monitored at five alluvial well locations (G-1A, G-2A, G-4A, AG-6, and AG-7) shown in Figure 2.3-7. Only the downstream well location (AG-6) near the confluence with the White River contains water.

2.3.3.3 Geohydrologic Properties

No off-tract water production figures were found for the Bird's Nest Aquifer within the area of investigation, but flume-measured flow rates during drilling on the tracts ranged from 0 to 700 gpm and averaged about 30 gpm. The wide range in production reflects, in part, the degree of aquifer saturation. The aquifer is nearly dry at well P-3 (south border of Tract Ub) and is dry at well G-19 (3 miles south of Tract Ub). The aquifer becomes increasingly saturated towards the northwest and attains an artesian head of up to 375 feet. The highest rate of water production (700 gpm) was measured at well P-2 (northern border of Tract Ua), which has about 240 feet of artesian head.

Aquifer tests were conducted during the summer of 1975 on wells P-1, P-2 Upper, P-2 Lower, and P-3 to determine the aquifer properties of transmissivity and storage coefficient. Drawdown and recovery were monitored in the pumped well and at two observation wells on each test site. Table 2.3-13 summarizes the aquifer properties determined from the testing program. The P-2 Upper well is completed to the Upper Aquifer. The base of this small aquifer lies just 75 feet above the top of the Bird's Nest Aquifer (P-2 Lower), but no interconnection between P-2 Upper and P-2 Lower was noted during the pumping.

2.3.3.4 Groundwater Movement

Because sufficient data for the water level beyond the boundaries at the tracts are not available, it can only be speculated that recharge water migrates along the northwest-dipping aquifer from the south and east, to

LEGEND:

- WELL RECEIVING WATER FROM THE BIRD'S NEST AQUIFER
- ▲ WELL RECEIVING WATER FROM THE UPPER AQUIFER
- WELL RECEIVING WATER FROM THE DOUGLAS CREEK AQUIFER

NOTE:

Wells G-13, G-16, G-16A, G-16B, G-19, G-20 are off of the map to the south.

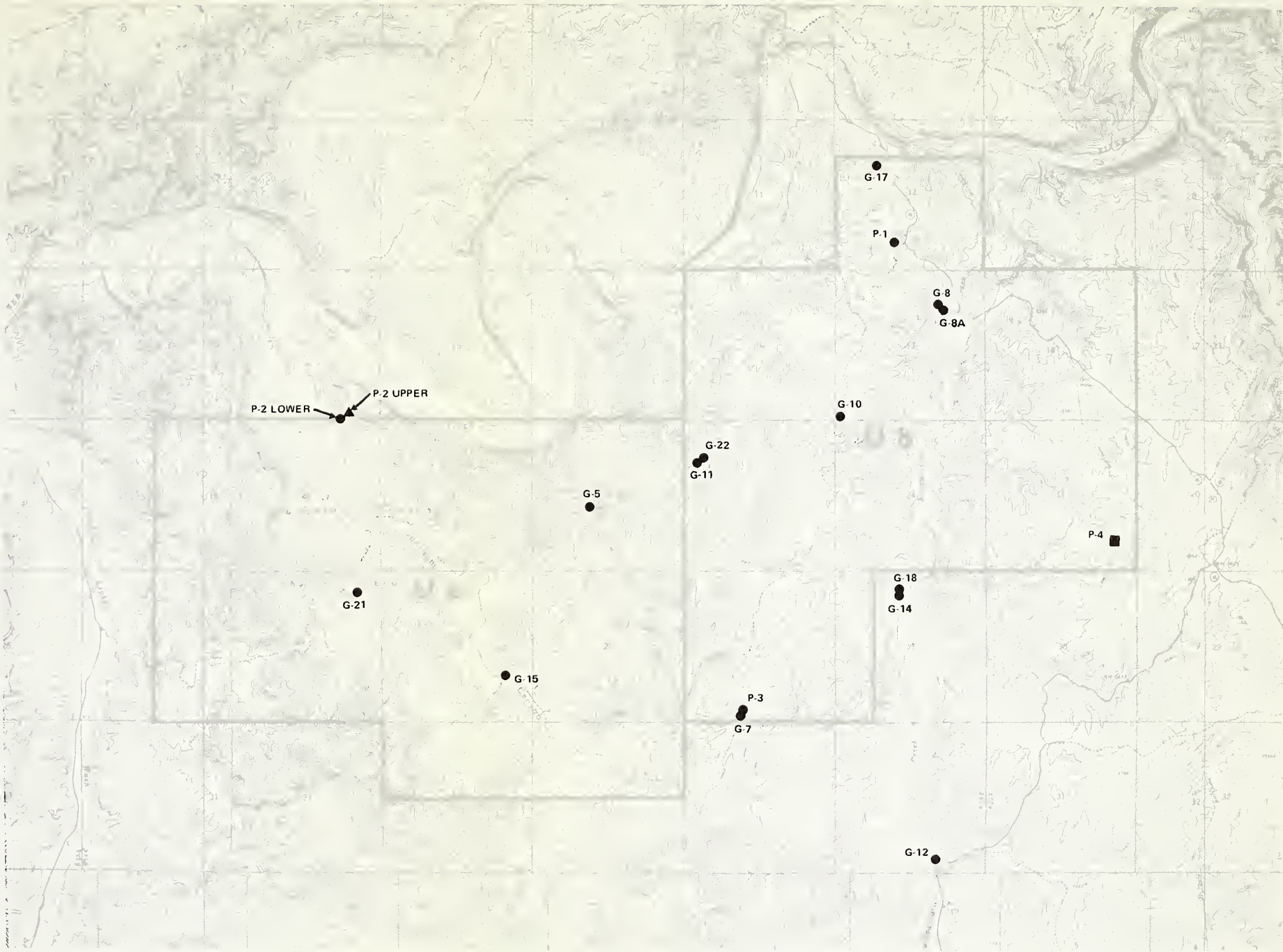


Figure 2.3-6 MONITORING LOCATIONS OF BEDROCK AQUIFERS

LEGEND:

● WELL(s)

NOTE:

HHC is an abbreviation for the USGS wells called "Hell's Hole Canyon."

ECPC is an abbreviation for the USGS wells called "Evacuation Creek near Park Canyon."

ECMC is an abbreviation for the USGS well called "Evacuation Creek above Missouri Creek."

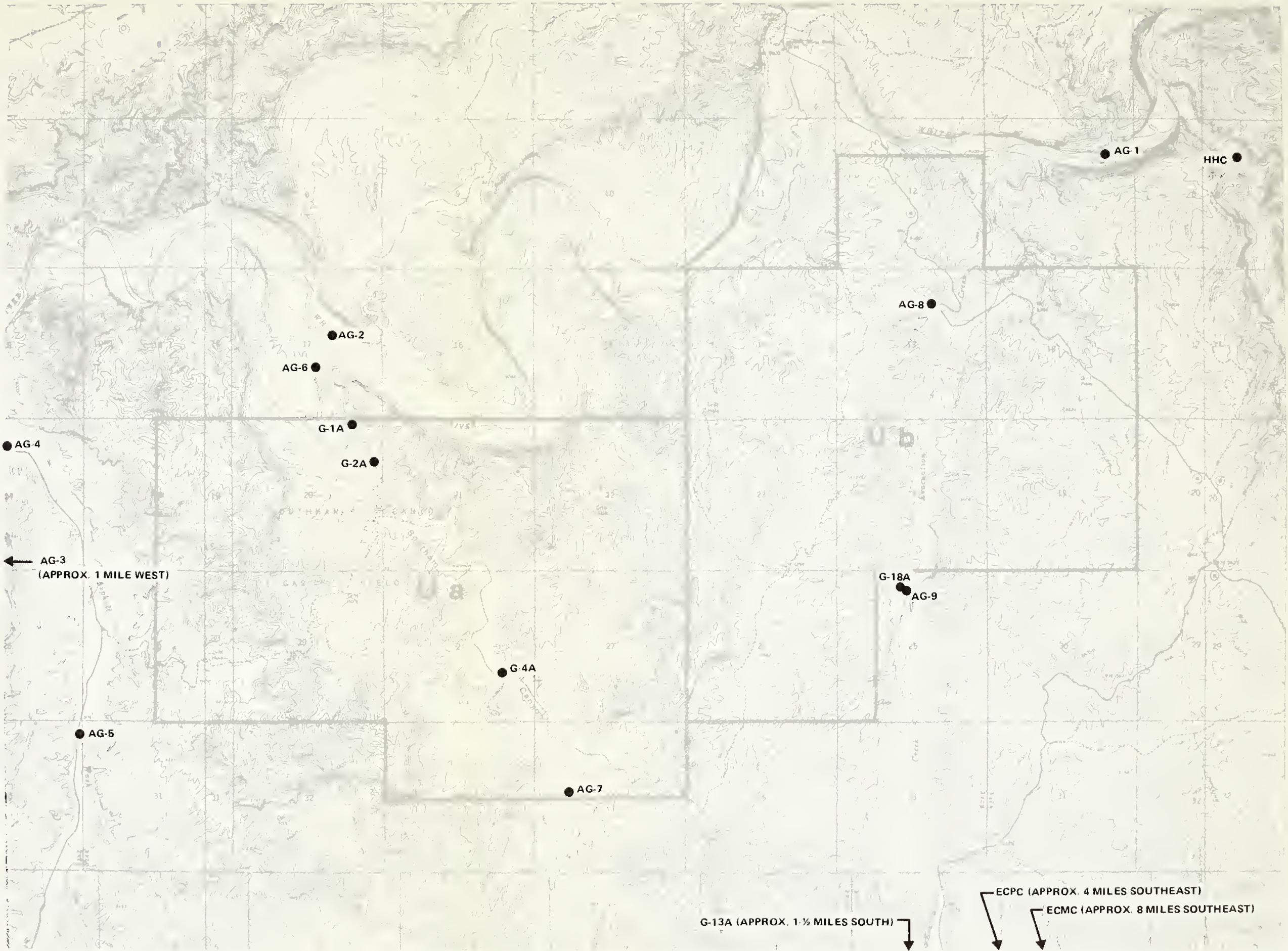


Figure 2.3-7 MONITORING LOCATIONS OF THE ALLUVIAL AQUIFERS

Table 2.3-13

SUMMARY OF AQUIFER TESTING

Property	Well Number			
	P-1	P-2 Upper	P-2 Lower	P-3
Static Water Level, ft	278.6	99.8	157.8	496.2
Depth to Top of Aquifer, ft	300	297	404	370
Aquifer Thickness, ft	135	30	96	110
Pumping Rate, gpm	45	10	500	3
Transmissivity, gpd/ft	1,500	150	75,000	15
Hydraulic Conductivity, gpd/ft ²	11.1	5.0	781.3	0.1
Storage Coefficient	3.52×10^{-4}	1.34×10^{-5}	6.01×10^{-5}	0.10
Test Period, hr	75.0	27.9	146.1	0.5

be discharged eventually along the White River below Evacuation Creek and along the entirety of Evacuation Creek across Tract Ub.

The site-specific contours of the piezometric surface provide clear evidence that the groundwater table slopes to the northwest in the same direction as the geologic structure. The groundwater level contours for March 1975 are shown in Figure 2.3-8. There has been no significant change in the contours since this date.

Present data indicate that intraformational or interformational leakage is not expected to be significant, since the major aquifer zones (Bird's Nest and Douglas Creek) appear to be well shielded from one another by an extensive thickness of shaly material.

2.3.3.5 Groundwater Recharge

The outcrop of the Green River Formation is shown on the geologic map (Figure 2.2-3). The Bird's Nest Aquifer is approximately 50 to 125 feet

below the upper contact of the Green River Formation. Therefore, the location of the aquifer can be assumed to occupy approximately the same position as this contact on the geologic map.

The regional extent of the Bird's Nest Aquifer is not known. However, the majority of recharge to the aquifer would be by lateral movement through the aquifer by interception of precipitation and runoff where it outcrops. The primary areas for recharge to the Bird's Nest Aquifer underlying the tracts is through its outcrop along Evacuation Creek and the White River. The relatively small surface area of outcrop exposed at this location and the low structural gradient of the aquifer (300 feet per mile) limit the rate at which recharge can occur. The portion of the aquifer to the east of Evacuation Creek probably receives recharge from its contact with alluvium in the bottom of Hells Hole Canyon.

2.3.3.6 Groundwater Discharge

Discharge from the aquifer, in the form of seeps and springs, is common along the down-dip portions of the aquifer on the east wall of Hells Hole and Evacuation Creek canyons. The groundwater in these areas is interrupted by the canyons before it can continue its northwesterly migration into the central part of the basin. The elevation of outcrop areas in Evacuation Creek (5,000 to 5,200 feet) corresponds to the approximate horizon at which the aquifer is not totally saturated and in some locations is dry. This is the result of discharge from the aquifer above the elevation of the outcrop located east of Evacuation Creek.

Seepage is especially prevalent in the northwest quarter of Section 13, T10S, R24E, where a flow of more or less consistent quality and quantity is provided to stream-gauging station 09306430. The aquifer is also in contact with the White River at an elevation of about 5,000 feet in the northeast quarter of Section 2, T10S, R24E, and discharges to the river at this location.

LEGEND

—5000— CONTOURS ON THE PIEZOMETRIC
SURFACE (INTERVAL 50 FEET)

NOTE:

Map adapted from reference 2-14.



Figure 2.3-8 CONTOUR MAP OF THE PIEZOMETRIC
SURFACE OF BIRD'S NEST AQUIFER,
MARCH 1975

2.3.3.7 Groundwater Fluctuations

Alluvial Aquifer Monitor Wells. During the baseline data collection program and the extended monitoring program, static water levels have been measured at 24 alluvial wells (see Figure 2.3-7 for well locations). During the five years of monitoring, water levels have fluctuated up to about 3 feet. Depth to water ranged from about 0 to 30 feet below the land surface, depending on well location. Generally, the lowest water levels within each well occurred during the baseflow periods, and the highest water levels occurred during periods of increased surface water flow.

Bedrock Aquifer Monitor Wells. These monitor wells are completed into water-bearing zones of the Uinta and Green River formations. During the baseline data collection program, and the extended monitoring program, static water levels have been measured at 21 wells exclusively monitoring the Bird's Nest Aquifer and 3 wells monitoring: (1) the aquifer above the Bird's Nest Aquifer in the Uinta Formation (the Upper Aquifer), 2) both the Bird's Nest and Douglas Creek aquifers, and 3) the Douglas Creek Aquifer. Well locations are widely distributed throughout the tracts (see Figure 2.3-6).

The static water levels of bedrock aquifer monitor wells for all three aquifers (Upper, Bird's Nest, and Douglas Creek) have not shown any significant variations. The depth to water within the Bird's Nest Aquifer increases to the northwest, in the direction of the dip of the aquifer, and ranges from zero at the outcrop areas along Evacuation Creek to about 500 feet in Tract Ua (well G-15). This corresponds to elevations from southeast to northwest of 5,450 to 4,830 feet above mean sea level.

2.3.3.8 Groundwater Storage and Change in Storage

Groundwater in storage includes the saturated portion of the aquifer and any volume of water under artesian pressure. In approximately 64 percent of the tracts, the aquifer is artesian with a minimum of 100 feet of

saturated thickness. However, aquifer conditions vary from dry in the southeastern portion of Tract Ub to at least 250 feet of artesian head in the northwest portion of Tract Ua. The amount of water available from artesian head is an insignificant amount in comparison with the estimated groundwater available in the saturated portion of the aquifer. The amount of groundwater in storage within the Bird's Nest Aquifer was estimated to be about 80,000 acre-feet.

As previously noted, the elevation of the static water levels fluctuates as a result of recharge and discharge. The data and observations available, however, suggest that as the water level rises, the discharge in Evacuation Creek (and presumably in the White River) increases. Thus, in its currently unstressed state, the level of the water surface in the Bird's Nest Aquifer is controlled more by the elevation of the discharge points (approximately 5,200 feet in Evacuation Creek Canyon) than by the amount of recharge. Because of these conditions and as the available record suggests, it is assumed that the long-term change in storage is zero. The records available for the period October 1974 through September 1979 suggest that the average net change in the Bird's Nest Aquifer water level was less than 1 foot for both artesian and water table responses.

2.3.3.9 Groundwater Quality

Discussions of regional groundwater quality throughout the Uinta Basin are provided by Feltis (Ref. 2-14) and Austin and Skogerboe (Ref. 2-11). The available data for groundwater from the Uinta Formation, Green River Formation, Wasatch Formation, and Mesa Verde Group suggest that, of the four sources, the groundwater from the Green River Formation consistently has the lowest concentration of total dissolved solids (TDS). In general, the best water quality occurs in the Book Cliffs area far south of the tracts.

A considerable amount of water quality information was obtained from bedrock aquifer wells drilled on and near the tracts as part of the baseline data

collection program. A comprehensive list of constituents was determined for each sample. These data are summarized in Table 2.3-14. The data have been divided into four groups: 1) the Bird's Nest Aquifer in the north-eastern portion of the tracts, 2) the Bird's Nest Aquifer in the south-western portion of the tracts, 3) the Upper Aquifer (in the Uinta Formation), and 4) the Douglas Creek Aquifer. The well numbers for each group are also given in the table. The locations of these wells are shown in Figure 2.3-6.

The water quality of the Bird's Nest Aquifer in the vicinity of the tracts ranges from brackish to moderately saline (878 mg/l to 6,000 mg/l of TDS). The terms used to classify salinity are described in Reference 2.15. The two groups of water quality data for this aquifer were divided based on the average concentrations of TDS. The group of wells in the northeastern portion of the tracts had an average TDS concentration of 4,030 mg/l, and the group of wells in the southwestern portion had an average value of 1,760 mg/l. The reasons for this variation are not clearly defined, but possible causes for the difference between the two groups are discussed in more detail in the Final Environmental Baseline Report (Ref. 2-1).

The water quality of the Upper Aquifer was found to be slightly saline (the mean concentration of TDS was 2,650 mg/l). The water quality data shown in Table 2.3-14 are from samples collected from well P-2 Upper, since this is the only location at which the aquifer was found to exist.

The groundwater of the Douglas Creek Aquifer had an average TDS concentration of 919 mg/l, which would be classified as slightly brackish water. The water quality data were from samples collected at wells P-4 and G-16A.

The water quality of the shallow alluvial aquifers in the vicinity of the tracts has also been investigated during the baseline study. The wells involved were located in the alluvium of five drainages: 1) White River, 2) Evacuation Creek, 3) Southam Canyon, 4) Asphalt Wash, and 5) Hells Hole

Canyon. At some locations, more than one well was installed and completed to either the upper or lower portions of the alluvial aquifer (these have been designated as upper or lower in addition to the well location designation). Tables 2.3-15, 2.3-16, and 2.3-17 summarize the water quality data for selected wells in the White River, Evacuation Creek, and the dry washes alluvium during the period January 1976 through September 1977.

It was determined that the water quality of these wells was remaining stable in time, with the exception of the wells at the AG-6 location. The concentration of TDS at these two wells decreased in time. Apparently, the alluvial water quality at this location may have been affected by the water released previously during pump testing in 1975 at well P-2 Lower; therefore, the data collected during 1976 and 1977 may not have been representative. The results of the most recent water quality analyses available at these two wells (September 21, 1979) are shown in Table 2.3-18. It is felt that these data are more representative of a baseline condition than the data shown in Table 2.3-17.

The average concentrations of TDS at the AG-1 location in the White River alluvium were 633 mg/l and 951 mg/l. At the AG-3 location, the average TDS values were much higher, ranging from 1,852 mg/l to 3,340 mg/l. The wells installed at three locations in the Evacuation Creek alluvium had similar TDS concentrations, ranging from 3,316 mg/l to 3,877 mg/l. The TDS values for the Southam Canyon wells (AG-6 location) were 924 mg/l and 1,200 mg/l in September 1979. Well AG-4 in Asphalt Wash had an average TDS concentration of 1,259 mg/l, and the Hells Hole Canyon wells had average values of 1,626 mg/l and 1,718 mg/l. These data indicate that the water quality of the alluvial aquifers in the vicinity of the tracts ranges from fresh to moderately saline.

2.3.3.10 Groundwater Use

Groundwater use is somewhat restricted by its quality. Springs and shallow alluvial wells supply users in the southern Uinta Basin with most of their

Table 2.3-14

SUMMARY OF GROUNDWATER QUALITY
FOR BIRD'S NEST, UPPER, AND
DOUGLAS CREEK AQUIFERS
OCTOBER 1974-SEPTEMBER 1979

			Bird's Nest Aquifer (NE) Well Numbers P-1, G-8, G-8A, G-10, G-11, G-12, G-14					Bird's Nest Aquifer (SW) Well Numbers P-2L, P-3, G-5, G-15, G-21					Upper Aquifer Well Number P-2U					Douglas Creek Aquifer Well Numbers P-4, G-16A				
Parameters			No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.
GENERAL CHARACTERISTICS	Alkalinity, Tot.	mg/l	47	616	383	1970	216	39	934	559	3010	240	12	510	34	554	434	9	675	136	817	482
	Dissolved Solids	mg/l	41	4030	959	6000	1430	36	1760	769	4350	878	12	2650	547	3200	1460	10	919	106	1090	826
	Hardness, Tot	mg/l	42	1000	330	1500	250	37	69	59	200	?	12	276	55	370	180	9	45	59	140	2
	Non-Carbonate Hardness	mg/l	43	480	340	980	0	37	0	0	0	0	12	0	0	0	0	9	0	0	0	0
	Oil and Grease	mg/l	42	2.5	4	21	0	36	3.5	4.5	24	0	10	5.5	12	39	0	9	1.6	1.5	4	0
	pH, field	units	41	7.9	7	11.4	7.3	41	9.0	7	10.7	7.4	11	8.1	.2	8.5	7.9	11	9.4	9	10.9	8.0
	Specific Conductance	umhos	47	4700	1170	6900	1130	42	510	1030	5300	300	12	3280	800	4200	1810	12	1470	162	1720	1300
	Temperature	°C	0	—	—	—	—	39	16.2	1.5	19.5	12.8	11	15.3	1.0	17.5	13.5	12	13.0	1.4	15.3	10.3
	Turbidity	Jtu	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—
MAJOR CATIONS	Calcium, Dis	mg/l	47	130	64	210	5.7	37	9.0	13	75	*1	12	28	4.8	36	19	9	3.8	4.0	10	7
	Magnesium	mg/l	44	170	40	260	67	41	11	9.8	30	3	12	49	12	68	30	9	8.2	11.4	27	0
	Potassium	mg/l	43	7.2	2.7	13	2.3	41	2.6	1.5	8.1	1.2	12	3.0	2.6	11.0	1.8	9	1.7	1.7	4.5	5
	Sodium, Dis	mg/l	42	890	270	1800	310	41	640	300	1700	300	12	776	156	940	450	9	356	31	430	320
	SAR		43	13	7.8	52	1.8	37	59	58	245	14	12	20	2.7	23	14	9	53	35	104	12
	% Sodium		43	64	12	98	34	37	95	4.9	100	84	12	86	2	88	83	9	94	7	100	83
	Strontium	ug/l	40	7100	3200	19,000	2200	37	1400	1200	4800	60	12	4550	1000	6400	2600	11	1700	2280	5000	40
MAJOR ANIONS	Bicarbonate	mg/l	47	681	467	2400	216	42	814	328	1710	201.6	12	622	42	675	529	9	657	79	753	510
	Carbonate	mg/l	47	4	19	117	0	41	147	220	1160	0	12	0	0	0	0	9	81	53	138	0
	Chloride	mg/l	47	75	37	280	36	36	130	160	580	31	12	59	12	82	36	9	75	102	230	6.8
	Sulfate	mg/l	47	2150	790	3300	180	36	400	220	1200	23	12	1360	370	1800	730	9	37	48	130	1.3
	Sulphide	mg/l	43	19	35	150	0	37	68	78	340	10	5	4	8	18	1	9	3.1	4.2	10	0
	Fluoride	mg/l	43	1.7	2.2	11	.2	40	3.0	3.9	21	.9	12	6	3	1.1	.4	9	1.3	6	2.4	9
	Bromide	mg/l	12	1.4	2.6	9.3	.3	9	2	2	6	0	3	5	4	9	.2	3	2	3	6	0
BIOCHEMICAL CONSTITUENTS	Carbon Dioxide	mg/l	38	22	17	81	0	37	5.1	10.5	61	0	11	8.4	3.6	14	3.3	8	2.3	3.5	9.4	0.0
	COD	mg/l	47	85	120	760	4	41	143	103	370	8	10	23	22	79	6	9	90	98	260	6
	SOC	mg/l	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—
	TOC	mg/l	31	20	16	66	4.6	27	15	14	66	2.3	7	7.9	6.6	43	13.0	7	26	27	57	3.1
	TIC	mg/l	23	61	89	378	0	13	78	113	386	0	4	156	125	258	0	4	72	87	176	0
	DOC	mg/l	9	15	10	34	5.0	5	11	9.3	22	2.9	1	1.7	0	1.7	1.7	2	10.1	9.8	17	3.2
MACRO NUTRIENTS	Ammonia	mg/l	42	78	86	2.9	00	35	1.6	1.7	8.1	43	11	1.9	76	3.9	53	9	1.7	1.1	3.5	65
	Nitrite	mg/l	42	01	.02	09	00	35	006	01	.04	.00	11	.01	01	04	00	9	004	004	02	00
	Nitrate	mg/l	35	05	11	51	00	35	.018	04	74	.00	11	01	01	04	00	9	03	04	.10	00
	Kjeldahl Nitrogen	mg/l	43	1.7	1.6	7.7	05	37	2.7	3.5	18	51	11	2.2	1.2	5.0	64	9	2.4	1.6	4.7	72
	Orthophosphate	mg/l	47	04	07	40	00	39	10	13	47	.00	11	02	02	05	01	9	11	05	20	05
	Total Phosphorus	mg/l	47	13	30	1.4	00	41	17	20	90	00	11	03	02	.06	.00	9	15	05	23	08
MICRO NUTRIENTS	Boron	ug/l	43	5500	13,000	78,000	30	36	3200	4800	26,000	400	12	375	230	1100	180	11	2010	2340	5200	80
	Copper	ug/l	39	2.5	3.7	19	0	37	< 7	10	44	0	12	1.8	2.6	7	0	11	< 2.6	3.9	14	0
	Iron	ug/l	43	680	1000	4600	20	37	140	110	730	5	12	110	80	280	10	11	80	48	180	30
	Manganese	ug/l	43	60	60	230	0	40	30	40	250	0	11	45	30	130	20	11	< 8.5	6	20	0
	Zinc	ug/l	43	70	90	490	0	37	30	50	280	0	12	20	20	80	0	11	15	10	30	0
	Molybdenum	ug/l	43	56	72	280	0	36	8	24	140	0	11	30	21	74	11	11	< 47	85	280	0
	Cobalt	ug/l	42	1.5	2	9	0	36	< 3	5	< 55	0	11	< 3	4	< 16	0	11	< 2.5	3.3	< 8	0
	Silica	mg/l	47	16	6.6	28	7.4	35	15	5.4	27	3.3	12	19	2	21	17	9	11.4	4.6	20	7.9

Table 2.3-14 (Continued)

		Bird's Nest Aquifer (NE) Well Numbers P-1, G-8, G-8A, G-10, G-11, G-12, G-14					Bird's Nest Aquifer (SW) Well Numbers P-2L, P-3, G-5, G-15, G-21					Upper Aquifer Well Number P-2U					Douglas Creek Aquifer Well Numbers P-4 and G-16A					
		No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	
TRACE METALS	Aluminum	μg/l	39	35	60	290	0	40	< 30	30	140	0	11	13	10	30	0	11	21	22	70	0
	Barium	μg/l	47	< 55	45	100	0	36	<120	140	600	0	11	< 48	44	100	0	11	145	120	400	0
	Beryllium	μg/l	43	< 8	6	20	0	36	< 6	5	20	0	11	< 7	7	20	0	11	< 4.4	6.4	20	0
	Bismuth	μg/l	37	< 45	32	<120	< 3	27	< 24	18	< 80	< 7	8	< 32	26	< 80	< 15	9	<11.5	9.5	< 30	< 6
	Cadmium	μg/l	43	< 1	3	1	0	36	< 1	.3	1	0	11	< 0	0	0	0	11	< .5	0	0	0
	Chromium	μg/l	39	< 20	25	< 85	0	36	< 10	9	< 55	0	10	< 12	18	< 60	0	0	—	—	—	—
	Gallium	μg/l	37	< 17	11	< 40	< 1	27	< 10	8	< 30	< 3	8	< 11	6	< 20	< 7	9	< 4.5	2	< 8	< 3
	Germanium	μg/l	37	< 55	45	<180	< 3	31	< 32	32	130	0	8	< 40	37	<120	< 10	9	< 14	.1	< 40	< 6
	Lead	μg/l	41	< 9	1.5	7	0	36	< 1	1	4	0	11	< 3	4	< 16	0	11	< 2.5	3.5	< 8	0
	Lithium	μg/l	41	470	380	1400	140	37	510	200	960	230	12	320	44	380	240	11	320	290	720	100
	Mercury	μg/l	40	< 6	9	4	0	37	< 1	5	2.8	0	12	< .02	.04	10	00	9	< .03	.04	< 1	0
	Selenium	μg/l	43	< 2.5	5	22	0	37	< 1	5	2	0	12	< 1	.3	10	0	9	< 0	0	0	0
	Silver	μg/l	43	< 2	4	1	0	36	< .06	2	1	0	11	< .15	.6	< 2	0	11	< 3	.5	< 1	0
	Tin	μg/l	37	< 42	27	< 85	< 3	27	< 23	14	< 60	< 7	8	< 32	19	< 60	< 15	9	< 9	7	< 20	< 6
	Titanium	μg/l	37	< 30	18	< 70	< 3	26	< 16	11	< 40	< 4	8	< 21	15	< 50	< 8	11	< 3	4	9.2	0
	Vanadium	μg/l	42	< 1.8	1.8	6.4	0	36	< 2.7	4.0	20	0	11	< 8	6	1.9	0	11	< 3	4	9.2	0
	Zirconium	μg/l	37	< 70	50	<200	< 5	27	< 38	30	<130	< 9	8	< 55	40	< 120	< 15	9	<18	11	< 40	< 9
TRACE NON-METALS	Arsenic	μg/l	43	< 10	11	50	0	37	< 31	46	210	0	12	< 9	9	25	0	9	< 240	390	1200	0
	Cyanide	mg/l	11	< .001	.003	.01	.00	8	< .00	.00	.00	.00	3	< .00	.00	.00	.00	3	< .007	.01	.02	.00
	Phenols	μg/l	12	< 3	3	12	0	9	< 3	2	7	0	3	< 5	2.5	7	2	3	< 30	50	90	0
	Pesticides	μg/l	1	< 0	0	0	0	1	< 0	0	0	0	1	< 0	0	0	0	1	< 0	0	0	0
	Herbicides	μg/l	1	< 0	0	0	0	1	< 0	0	0	0	1	< 0	0	0	0	1	< 0	0	0	0
RADIOACTIVE CONSTITUENTS	Cesium 137, Dis.	PC/l	24	< 1	2	2	< 1	25	< 1.1	2	1.8	< 1.0	6	< 1.0	0	< 1.0	< 1.0	7	< 1.0	0	< 1.0	< 1.0
	Gross A, Dis., U-Nat.	μg/l	37	< 63	40	220	< 6.2	31	< 26	13	< 71	< 14	10	< 27	8.5	< 37	< 9.7	8	< 16	8.2	35	< 9.8
	Gross A, Sus., U-Nat.	μg/l	9	< 1	7	2	< 4	4	< 1.9	1.1	2.8	< 4	3	< 4	0	< 4	< 4	2	< .5	15	6	< 4
	Gross B, Dis., Cs 137	PC/l	37	< 23	19	98	< 6.0	31	< 8.4	3.8	17	< 4.0	10	< 9.7	8.1	32	< 4.8	6	< 5.9	3.4	10	< 2.7
	Gross B, Sus., Cs 137	PC/l	9	< 3.4	3.2	9.3	4	4	< 1.3	6	1.9	< .5	3	< 4	0	< 4	< 4	2	< 1	8	1.5	< 4
	Gross B, Dis., Sr90/Y90	PC/l	37	< 19	16	83	< 5.3	29	< 6.1	3.2	< 13	< .5	10	< 10	7	27	< 4.4	8	< 22	48	140	< 2.2
	Gross B, Sus., Sr90/Y90	PC/l	9	< 3.0	2.8	8.1	4	4	< 1.1	5	1.6	< .5	3	< 4	0	< 4	< 4	2	< 9	6	1.3	< 4
	Potassium 40, Dis.	PC/l	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—
	Ra 226 BY Rn	PC/l	38	< 25	14	.50	< .01	29	< 25	19	.75	< .01	8	< .19	13	< 40	.08	8	< 1.7	3.8	11	.13
	Residue, Tot., Fil., 105°C	mg/l	0	—	—	—	—	0	—	—	—	—	8	2800	280	3200	1200	0	—	—	—	—
	U Dis	PC/l	20	<7.0	7.6	24	< .01	21	< 65	50	1.6	.05	8	< 26	12	43	.04	6	< .33	.50	1.2	< .01
	U Dis, Dir., Flour	μg/l	12	< 16	9.0	27	1.3	3	< 1.1	1	1.2	1.0	1	< 1.2	0	1.2	1.2	3	< 9	1.1	2.1	0
	U Dis, Nat	μg/l	7	< 17	27	77	4	5	< 2.5	1.8	5.6	1.0	0	—	—	—	—	0	—	—	—	—

Table 2.3-15

SUMMARY OF ALLUVIAL WATER QUALITY FOR
WHITE RIVER ALLUVIUM,
JANUARY 1976-SEPTEMBER 1977

			AG-1-1 (LOWER)					AG-1-1 (UPPER)					AG-3-1 (LOWER)					AG-3-2 (UPPER)					AG-3-3 (UPPER)				
Parameters			No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	(mg/l)	5	346	42	416	318	2	319	63	363	274	6	470	18	497	445	5	384	14	401	367	7	486	39	550	424
	Dissolved Solids	(mg/l)	5	633	21	649	597	2	951	42	980	921	6	3340	344	3630	2680	6	1852	51	1900	1770	7	2796	383	3650	2570
	Hardness as Ca, Mg	(mg/l)	5	78	6	89	73	2	425	35	450	400	6	1388	237	1600	930	5	562	23	590	530	7	1084	187	1500	990
	Noncarbonate Hardness	(mg/l)	5	0	0	0	0	2	106	91	170	41	6	935	253	1200	470	5	180	33	210	140	7	609	218	1100	480
	Oil and Grease	(mg/l)	1	6	--	6	6	1	4	--	4	4	1	3	--	3	3	0	--	--	--	--	1	2	--	2	2
	pH		5	8.0	0.3	8.2	7.5	3	7.9	0.2	8.1	7.7	5	7.8	0.2	8.0	7.6	5	7.7	0.2	8.0	7.5	7	7.9	0.3	8.3	7.4
	Specific Conductance	(umhos/cm)	5	964	106	1150	900	3	1467	247	1750	1300	5	4132	365	4400	3490	5	2660	115	2800	2500	8	3394	336	3800	2800
	Temperature	(°C)	5	9.8	1.7	11.7	7.4	3	11.2	3.9	14.7	7.0	6	10.8	1.7	13.5	9.0	5	11.0	2.4	13.5	8.5	8	10.6	1.7	12.6	8.3
	Turbidity	(JTU)	1	450	--	450	450	1	450	--	450	450	0	--	--	--	--	0	--	--	--	--	1	130	--	130	130
Color	(PCU)	5	82	103	200	20	2	25	7	30	20	1	5	--	5	5	0	--	--	--	--	5	12	5	20	7	
MAJOR CATIONS	Calcium	(mg/l)	5	13	2	16	11	2	105	7	110	100	6	238	43	280	160	5	73	6	80	65	7	187	33	260	170
	Magnesium	(mg/l)	5	11.2	0.5	12	11	2	39	3	41	37	6	195	35	230	130	5	93	3	97	90	7	151	27	210	130
	Potassium	(mg/l)	5	2.5	0.3	3.0	2.2	2	5.8	0.3	6.0	5.6	6	4.8	0.7	5.5	3.8	5	3.4	0.5	3.7	2.6	7	4.2	0.8	5.6	3.5
	Sodium	(mg/l)	5	204	5	210	200	2	155	7	160	150	6	572	25	600	540	5	418	16	440	400	7	533	39	610	500
	Sodium Adsorption Ratio		5	10.1	0.5	11	9.7	2	3.3	0.0	3.3	3.3	6	6.7	0.5	7.7	6.1	5	7.7	0.4	8.1	7.2	7	7.0	0.2	7.3	6.8
	Percent Sodium		5	85	1	85	83	2	44	0	44	44	6	48	4	56	44	5	62	2	64	59	7	51	2	53	47
	Strontium	(ug/l)	3	430	26	460	410	2	1500	0	1500	1500	1	3400	--	3400	3400	0	--	--	--	--	5	2380	164	2500	2200
MAJOR ANIONS	Bicarbonate	(mg/l)	5	399	19	433	388	2	388	76	442	334	6	573	23	606	542	5	468	17	489	448	7	593	47	670	517
	Carbonate	(mg/l)	4	0	0	0	0	2	0	0	0	0	5	0	0	0	0	4	0	0	0	0	6	0	0	0	0
	Chloride	(mg/l)	5	52	2	55	51	2	96	21	110	81	6	173	19	190	140	5	101	14	110	79	7	144	21	190	130
	Sulfate	(mg/l)	5	115	17	130	85	2	340	42	370	310	6	1850	243	2100	1400	5	912	47	940	830	7	1457	294	2100	1300
	Sulfide	(mg/l)	3	9.1	5.5	14	3.2	2	0.0	0.0	0.0	0.0	1	0.0	--	0.0	0.0	0	--	--	--	--	5	0.7	1.3	3.0	0.0
	Fluoride	(mg/l)	5	2.5	0.2	2.7	2.3	2	0.65	0.07	0.7	0.6	6	0.4	0.2	0.7	0.2	5	1.1	0.1	1.2	0.9	7	0.6	0.1	0.7	0.4
	Bromide	(mg/l)	1	0.3	--	0.3	0.3	1	0.3	--	0.3	0.3	1	0.6	--	0.6	0.6	0	--	--	--	--	1	0.5	--	0.5	0.5
BIO-CHEM. CONST.	Chemical Oxygen Demand	(mg/l)	1	52	--	52	52	1	92	--	92	92	1	91	--	91	91	0	--	--	--	--	1	76	--	76	76
	Carbon Dioxide	(mg/l)	0	--	--	--	--	0	--	--	--	--	2	13	3	15	11	2	21	4	23	18	2	23.9	27.1	43	4.7
	Dissolved Organic Carbon	(mg/l)	3	10.5	5.2	16	5.6	2	33	8	39	27	1	4.9	--	4.9	4.9	0	--	--	--	--	4	23	2	25	21
MACRONUTRIENTS	Ammonia as N	(mg/l)	3	0.29	0.04	0.32	0.25	2	0.54	0.03	0.56	0.52	1	0.62	--	0.62	0.62	0	--	--	--	--	5	0.67	0.08	0.74	0.54
	Nitrite as N	(mg/l)	3	0.003	0.006	0.01	0.00	2	0.01	0.00	0.01	0.01	1	0.00	--	0.00	0.00	0	--	--	--	--	5	0.03	0.07	0.16	0.00
	Nitrate as N	(mg/l)	3	0.08	0.06	0.14	0.02	2	0.24	0.03	0.26	0.22	0	--	--	--	--	0	--	--	--	--	5	0.08	0.08	0.22	0.01
	Nitrite and Nitrate as N	(mg/l)	5	0.07	0.05	0.14	0.03	2	0.25	0.03	0.27	0.23	5	0.04	0.03	0.07	0.00	4	0.035	0.021	0.06	0.00	6	0.10	0.14	0.38	0.01
	Total Kjeldahl Nitrogen as N	(mg/l)	3	1.16	0.42	1.6	0.77	2	6.1	5.2	9.8	2.4	1	1.7	--	1.7	1.7	0	--	--	--	--	5	2.6	1.3	4.6	1.1
	Total Phosphorus as P	(mg/l)	3	0.32	0.16	0.48	0.17	2	3.11	3.95	5.9	0.31	1	0.09	--	0.09	0.09	0	--	--	--	--	5	1.11	0.53	1.9	0.48
	Diss. Ortho Phosphorus as P	(mg/l)	5	0.08	0.02	0.10	0.05	2	0.005	0.007	0.01	0.00	5	0.016	0.012	0.03	0.00	4	0.020	0.008	0.03	0.01	6	0.010	0.006	0.02	0.00
	Diss. Ortho Phosphate as PO ₄	(mg/l)	5	0.23	0.07	0.31	0.15	2	0.015	0.021	0.03	0.00	1	0.03	--	0.03	0.03	1	0.03	--	0.03	0.03	6	0.03	0.02	0.06	0.00

Table 2.3-15 (Continued)

			AG-1-1 (LOWER)					AG-1-1 (UPPER)					AG-3-1 (LOWER)					AG-3-2 (UPPER)					AG-3-3 (UPPER)				
Parameters			No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.
MICRONUTRIENTS	Boron	(ug/l)	5	1340	182	1500	1100	2	265	35	290	240	6	4017	2032	6900	1200	5	3280	1580	6000	2000	7	3097	2084	6900	1700
	Copper	(ug/l)	3	2.3	1.5	4	1	2	3.5	0.7	4	3	1	2	--	2	2	0	--	--	--	--	5	4.0	4.1	11	1
	Iron	(ug/l)	4	128	129	320	40	2	30	14	40	20	2	50	28	70	30	1	80	--	80	80	6	245	259	650	20
	Manganese	(ug/l)	4	20	8	30	10	2	425	64	470	380	2	380	0	380	380	1	280	--	280	280	6	410	65	460	300
	Zinc	(ug/l)	3	13	15	30	0	2	10	0	10	10	1	860	--	860	860	0	--	--	--	--	5	40	24	80	20
	Molybdenum	(ug/l)	3	0	0	0	0	2	38	3	40	36	1	18	--	18	18	0	--	--	--	--	5	15	5	21	10
	Silica	(mg/l)	5	21	2	23	19	2	13.5	0.7	14	13	6	17.7	1.4	20	16	5	16.4	1.1	18	15	7	17.6	1.1	19	16
TRACE METALS	Aluminum	(ug/l)	3	37	32	60	0	2	25	21	40	10	1	0	--	0	0	0	--	--	--	--	5	22	15	40	0
	Barium	(ug/l)	3	100	100	200	0	2	150	212	300	0	1	0	--	0	0	0	--	--	--	--	5	0	0	0	0
	Cadmium	(ug/l)	3	0.3	0.6	1	0	2	0	0	0	0	1	0	--	0	0	0	--	--	--	--	5	0.4	0.6	1	0
	Total Chromium	(ug/l)	3	30	10	40	20	2	350	424	650	50	1	10	--	10	10	0	--	--	--	--	5	64	21	80	30
	Lead	(ug/l)	3	1.0	1.7	3	0	2	0	0	0	0	1	8	--	8	8	0	--	--	--	--	5	2.4	3.9	9	0
	Lithium	(ug/l)	3	60	0	60	60	3	30	0	30	30	1	130	--	130	130	0	--	--	--	--	5	100	7	110	90
	Mercury	(ug/l)	2	0.15	0.21	0.3	0.0	1	0.2	--	0.2	0.2	1	0.1	--	0.1	0.1	0	--	--	--	--	5	0.14	0.15	0.3	0.0
	Selenium	(ug/l)	2	0	0	0	0	1	0	--	0	0	1	0	--	0	0	0	--	--	--	--	5	0	0	0	0
TRACE NON-METALS	Vanadium	(ug/l)	3	2.0	2.2	4.4	0.2	2	4.8	1.7	6.0	3.6	1	1.4	--	1.4	1.4	0	--	--	--	--	5	2.5	0.9	3.7	1.4
	Arsenic	(ug/l)	2	0.5	0.7	1	0	1	5	--	5	5	1	1	--	1	1	0	--	--	--	--	5	6	2	8	4
	Cyanide	(mg/l)	3	0.00	0.00	0.00	0.00	2	0.00	0.00	0.00	0.00	1	0.00	--	0.00	0.00	0	--	--	--	--	5	0.002	0.004	0.01	0.00
	Phenols	(ug/l)	1	1	--	1	1	1	1	--	1	1	1	2	--	2	2	0	--	--	--	--	1	0	--	0	0
	Pesticides	(ug/l)	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--	1	0	--	0	0
RADIOACTIVE CONST.	Herbicides	(ug/l)	0	--	--	--	--	1	0	--	0	0	0	--	--	--	--	0	--	--	--	--	1	0	--	0	0
	Gross Alpha as U-nat.	(ug/l)	1	<8.5	--	<8.5	<8.5	1	<12	--	<12	<12	0	--	--	--	--	0	--	--	--	--	1	<35	--	<35	<35
	Gross Beta as Sr 90	(pCi/l)	1	4.3	--	4.3	4.3	1	7.9	--	7.9	7.9	0	--	--	--	--	0	--	--	--	--	1	<7.3	--	<7.3	<7.3
	Gross Beta as Ce 137	(pCi/l)	1	5.1	--	5.1	5.1	1	9.8	--	9.8	9.8	0	--	--	--	--	0	--	--	--	--	1	<9.0	--	<9.0	<9.0
	Potassium 40	(pCi/l)	1	1.7	--	1.7	1.7	1	4.3	--	4.3	4.3	0	--	--	--	--	0	--	--	--	--	1	3.0	--	3.0	3.0
	Radium 226, radon method	(pCi/l)	1	0.07	--	0.07	0.07	0	--	--	--	--	1	0.12	--	0.12	0.12	0	--	--	--	--	1	0.07	--	0.07	0.07
	Diss. Uranium, dir. fluorometric	(ug/l)	1	0.5	--	0.5	0.5	0	--	--	--	--	1	2.2	--	2.2	2.2	0	--	--	--	--	1	1.5	--	1.5	1.5

Table 2.3-16

SUMMARY OF ALLUVIAL WATER QUALITY FOR
EVACUATION CREEK ALLUVIUM,
JANUARY 1976-SEPTEMBER 1977

			AG-8					EVACUATION CREEK NEAR PARK CANYON-1 (LOWER)					EVACUATION CREEK NEAR PARK CANYON-2 (UPPER)					EVACUATION CREEK ABOVE MISSOURI CREEK-1 (LOWER)				
Parameters			No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	(mg/l)	7	427	49	456	320	5	463	55	508	369	5	461	6	470	455	5	423	22	450	395
	Dissolved Solids	(mg/l)	7	3877	122	4010	3650	5	3416	168	3540	3130	5	3804	101	3950	3710	5	3316	45	3350	3240
	Hardness as Ca, Mg	(mg/l)	7	1171	76	1300	1100	5	1176	173	1300	880	5	1380	45	1400	1300	5	762	41	800	710
	Noncarbonate Hardness	(mg/l)	7	747	62	860	690	5	718	192	850	380	5	894	49	930	810	5	338	52	390	260
	Oil and Grease	(mg/l)	1	19	--	19	19	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	pH		8	7.9	0.3	8.4	7.4	5	7.7	0.3	8.1	7.4	5	7.7	0.3	8.2	7.4	5	7.8	0.2	8.1	7.5
	Specific Conductance	(umhos/cm)	8	4550	650	5200	3100	5	4326	181	4500	4060	5	4580	133	4690	4370	5	4366	159	4600	4190
	Temperature	(°C)	7	12.3	2.5	14.4	8.3	5	10.9	2.4	14.0	7.5	5	11.4	4.5	18.0	7.5	5	11.1	2.9	13.0	6.0
	Turbidity	(JTU)	1	4500	--	4500	4500	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Color	(PCU)	5	32	36	90	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
MAJOR CATIONS	Calcium	(mg/l)	7	171	12	190	160	5	166	5	170	160	5	200	12	210	180	5	81	6	88	75
	Magnesium	(mg/l)	7	180	16	210	160	5	186	43	210	110	5	208	4	210	200	5	136	11	150	120
	Potassium	(mg/l)	7	9.4	1.8	12	7.0	5	6.4	0.5	7.1	5.7	5	7.2	1.0	8.3	5.8	5	9.0	2.1	12	6.3
	Sodium	(mg/l)	7	819	25	850	780	5	672	11	680	660	5	726	15	740	700	5	806	9	820	800
	Sodium Adsorption Ratio		7	10.4	0.6	11	9.6	5	8.6	0.8	10	8.0	5	8.6	0.3	8.9	8.2	5	12.8	0.5	13	12
	Percent Sodium		7	60	2	63	57	5	56	4	63	53	5	54	1	55	53	5	69	1	71	68
	Strontium	(ug/l)	5	3680	638	4300	3000	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
MAJOR ANIONS	Bicarbonate	(mg/l)	7	520	60	556	390	5	563	67	619	450	5	562	6	570	555	5	516	27	550	481
	Carbonate	(mg/l)	7	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0
	Chloride	(mg/l)	7	64	13	93	54	5	53	2	54	50	5	50	4	53	43	5	37	4	43	31
	Sulfate	(mg/l)	7	2357	98	2500	2200	5	2040	152	2200	1800	5	2280	84	2400	2200	5	1980	45	2000	1900
	Sulfide	(mg/l)	5	0.7	0.1	1.1	0.9	5	1.64	0.05	1.7	1.6	0	--	--	--	--	0	--	--	--	--
	Fluoride	(mg/l)	7	1.0	0.1	1.1	0.9	5	1.64	0.05	1.7	1.6	5	1.7	0.1	1.8	1.6	5	0.98	0.15	1.2	0.8
	Bromide	(mg/l)	1	0.2	--	0.2	0.2	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
BIO- CHEM. CONST.	Chemical Oxygen Demand	(mg/l)	1	79	--	79	79	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Carbon Dioxide	(mg/l)	0	--	--	--	--	2	30	10	37	23	2	25	16	36	14	2	22	8	28	16
	Dissolved Organic Carbon	(mg/l)	5	16.6	0.6	17	16	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
MACRONUTRIENTS	Ammonia as N	(mg/l)	5	0.094	0.038	0.14	0.04	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Nitrite as N	(mg/l)	5	0.016	0.030	0.07	0.00	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Nitrate as N	(mg/l)	5	0.130	0.037	0.17	0.07	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Nitrite and Nitrate as N	(mg/l)	6	0.13	0.07	0.24	0.04	4	0.09	0.09	0.17	0.01	4	10.7	0.6	11	9.9	4	9.12	0.04	0.14	0.06
	Total Kjeldahl Nitrogen as N	(mg/l)	5	18.5	29.1	70	1.5	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Total Phosphorus as P	(mg/l)	5	2.87	3.17	7.4	0.21	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Diss. Ortho Phosphorus as P	(mg/l)	6	0.007	0.005	0.01	0.00	4	0.010	0.008	0.02	0.00	4	0.013	0.013	0.03	0.00	4	0.010	0.008	0.02	0.00
	Diss. Ortho Phosphate as PO ₄	(mg/l)	6	0.020	0.015	0.03	0.00	1	0.03	--	0.03	0.03	1	0.03	--	0.03	0.03	1	0.03	--	0.03	0.03

Table 2.3-16 (Continued)

			AG-8					EVACUATION CREEK NEAR PARK CANYON-1 (LOWER)					EVACUATION CREEK NEAR PARK CANYON-2 (UPPER)					EVACUATION CREEK ABOVE MISSOURI CREEK-1 (LOWER)				
Parameters			No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.
MICRONUTRIENTS	Boron	(ug/l)	6	2850	1701	6100	1300	5	2560	182	2800	2300	5	1940	134	2100	1800	5	198	38	220	130
	Copper	(ug/l)	5	3.2	1.5	5	1	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Iron	(ug/l)	6	50	28	100	20	1	40	--	40	40	1	40	--	40	40	1	30	--	30	30
	Manganese	(ug/l)	6	780	303	1200	470	1	510	--	510	510	1	30	--	30	30	1	160	--	160	160
	Zinc	(ug/l)	5	10	10	20	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Molybdenum	(ug/l)	5	43	12	55	25	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Silica	(mg/l)	7	10.8	0.7	12	9.8	5	8.9	0.6	9.9	8.3	5	13	1	14	12	5	11.4	1.1	13	10
TRACE METALS	Aluminum	(ug/l)	5	24	5	30	20	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Barium	(ug/l)	5	40	55	100	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Cadmium	(ug/l)	5	0	0	0	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Total Chromium	(ug/l)	5	176	186	500	60	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Lead	(ug/l)	5	0	0	0	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Lithium	(ug/l)	5	148	13	160	130	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Mercury	(ug/l)	5	0.2	0.2	0.4	0.0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Selenium	(ug/l)	5	0.2	0.5	1	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Vanadium	(ug/l)	5	0.9	0.5	1.3	0.2	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
TRACE NON-METALS	Arsenic	(ug/l)	5	2	1	3	1	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Cyanide	(mg/l)	5	0.002	0.004	0.01	0.00	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Phenols	(ug/l)	1	3	--	3	3	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Pesticides	(ug/l)	1	0	--	0	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Herbicides	(ug/l)	1	0	--	0	0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
RADIOACTIVE CONST.	Gross Alpha as U-nat.	(ug/l)	1	<45	--	<45	<45	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Gross Beta as Sr 90	(pCi/l)	1	15	--	15	15	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Gross Beta as Ce 137	(pCi/l)	1	18	--	18	18	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Potassium 40	(pCi/l)	1	8.0	--	8.0	8.0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Radium 226, radon method	(pCi/l)	1	0.07	--	0.07	0.07	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
	Diss. Uranium, dir. fluorometric	(ug/l)	1	20.0	--	20.0	20.0	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--

Table 2.3-17

SUMMARY OF ALLUVIAL WATER QUALITY FOR
 DRY WASHES ALLUVIUM,
 JANUARY 1976-SEPTEMBER 1977

			AG-6-1 (LOWER)					AG-6-2 (UPPER)					AG-4					HELL'S HOLE CANYON-1 (LOWER)					HELL'S HOLE CANYON-2 (UPPER)				
Parameters			No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃	(mg/l)	10	284	9	305	274	5	296	21	323	271	7	483	47	556	428	5	846	119	980	721	5	782	70	900	712
	Dissolved Solids	(mg/l)	10	6222	469	6710	5310	5	3506	788	4490	2420	7	1259	272	1680	975	5	1626	33	1680	1600	5	1718	130	1910	1550
	Hardness as Ca, Mg	(mg/l)	10	3060	384	3500	2300	5	1760	445	2300	1100	7	240	89	380	150	5	107	25	150	91	5	100	17	130	86
	Noncarbonate Hardness	(mg/l)	10	2760	360	3200	2100	5	1428	477	2000	740	7	0	0	0	0	5	0	0	0	0	5	0	0	0	0
	Oil and Grease	(mg/l)	1	2	--	2	2	0	--	--	--	--	1	2	--	2	2	0	--	--	--	--	0	--	--	--	--
	pH		8	7.8	0.2	8.1	7.7	4	7.6	0.2	7.8	7.4	7	7.9	0.2	8.2	7.5	4	8.9	0.5	9.5	8.5	5	9.0	0.3	9.4	8.7
	Specific Conductance	(umhos/cm)	10	6536	464	7250	5600	5	4260	798	5000	3000	7	1831	457	2600	1370	5	2505	212	2750	2250	5	2680	135	2850	2500
	Temperature	(°C)	10	12.0	1.0	13.5	10.0	5	12.2	1.4	13.5	10.0	7	12.3	1.0	13.9	11.0	5	12.2	1.5	14.0	11.0	5	12.5	1.7	14.0	10.0
	Turbidity	(JTU)	0	--	--	--	--	0	--	--	--	--	1	85	--	85	85	0	--	--	--	--	0	--	--	--	--
	Color	(PCU)	4	0.8	1.5	3	0	0	--	--	--	--	5	22	16	40	5	0	--	--	--	--	0	--	--	--	--
MAJOR CATIONS	Calcium	(mg/l)	10	637	89	790	510	5	350	91	440	210	7	17.4	6.2	26	9.9	5	10.8	7.9	24	5.0	5	8.2	2.1	11	6.1
	Magnesium	(mg/l)	10	354	40	390	260	5	210	58	290	130	7	48	18	77	30	5	20	1	21	18	5	20	4	27	17
	Potassium	(mg/l)	10	7.1	1.1	8.7	5.5	5	6.8	1.0	7.7	5.2	7	2.1	0.6	2.9	1.2	5	3.8	1.0	5.2	2.5	5	3.3	0.5	3.8	2.5
	Sodium	(mg/l)	10	789	45	850	730	5	460	53	520	380	7	371	59	460	300	5	570	14	590	550	5	594	29	630	550
	Sodium Adsorption Ratio		10	6.3	0.5	6.8	5.5	5	4.9	0.2	5.1	4.7	7	10.4	0.5	11	10	5	24	2	26	21	5	26	1	27	24
	Percent Sodium		10	36	3	40	32	5	37	4	44	33	7	77	4	82	72	5	92	2	93	89	5	92	1	93	91
	Strontium	(ug/l)	4	7225	2985	11000	4500	0	--	--	--	--	5	874	231	1200	610	0	--	--	--	--	0	--	--	--	--
MAJOR ANIONS	Bicarbonate	(mg/l)	10	346	11	372	334	5	361	25	394	330	7	588	58	678	522	5	931	98	1080	825	5	875	82	960	764
	Carbonate	(mg/l)	7	0	0	0	0	3	0	0	0	0	6	0	0	0	0	4	62	74	168	0	4	48	24	66	13
	Chloride	(mg/l)	10	238	26	280	190	5	113	24	130	73	7	51	9	69	42	5	70	62	180	39	5	84	45	150	42
	Sulfate	(mg/l)	10	3970	330	4400	3400	5	2160	577	2900	1400	7	437	140	650	280	5	424	131	560	230	5	524	150	730	380
	Sulfide	(mg/l)	4	0.0	0.0	0.0	0.0	0	--	--	--	--	5	0.6	1.4	3.2	0.0	0	--	--	--	--	0	--	--	--	--
	Fluoride	(mg/l)	10	0.4	0.3	1.0	0.2	5	0.3	0.0	0.3	0.3	7	4.5	1.8	5.8	0.7	5	6.2	0.7	6.9	5.0	5	5.3	0.7	5.9	4.3
	Bromide	(mg/l)	1	0.7	--	0.7	0.7	0	--	--	--	--	1	0.2	--	0.2	0.2	0	--	--	--	--	0	--	--	--	--
BIO-CHEM. CONST.	Chemical Oxygen Demand	(mg/l)	1	36	--	36	36	0	--	--	--	--	1	35	--	35	35	0	--	--	--	--	0	--	--	--	--
	Carbon Dioxide	(mg/l)	1	6.9	--	6.9	6.9	1	15	--	15	15	3	8.3	0.4	8.6	7.9	1	5.1	--	5.1	5.1	2	1.6	0.9	2.2	0.9
	Dissolved Organic Carbon	(mg/l)	4	8.5	2.1	11	6.0	0	--	--	--	--	5	13.2	4.2	19	9.0	0	--	--	--	--	0	--	--	--	--
MACRONUTRIENTS	Ammonia as N	(mg/l)	4	0.08	0.05	0.14	0.01	0	--	--	--	--	5	0.03	0.02	0.07	0.01	0	--	--	--	--	0	--	--	--	--
	Nitrite as N	(mg/l)	4	0.30	0.10	0.38	0.16	0	--	--	--	--	5	0.022	0.027	0.06	0.00	0	--	--	--	--	0	--	--	--	--
	Nitrate as N	(mg/l)	0	--	--	--	--	0	--	--	--	--	5	5.4	2.9	9.3	2.3	0	--	--	--	--	0	--	--	--	--
	Nitrite and Nitrate as N	(mg/l)	10	6.6	1.3	8.7	4.8	5	1.43	0.49	2.0	0.92	6	5.2	2.7	9.3	2.3	4	0.038	0.075	0.15	0.00	4	0.035	0.051	0.11	0.00
	Total Kjeldahl Nitrogen as N	(mg/l)	4	1.67	1.22	3.3	0.63	0	--	--	--	--	5	1.66	0.57	2.3	0.98	0	--	--	--	--	0	--	--	--	--
	Total Phosphorus as P	(mg/l)	4	2.89	3.89	8.7	0.46	0	--	--	--	--	5	0.37	0.18	0.57	0.18	0	--	--	--	--	0	--	--	--	--
	Diss. Ortho Phosphorus as P	(mg/l)	10	0.020	0.013	0.04	0.00	2	0.025	0.007	0.03	0.02	6	0.025	0.010	0.04	0.01	4	0.14	0.18	0.40	0.03	4	0.053	0.043	0.10	0.00
	Diss. Ortho Phosphate as PO ₄	(mg/l)	3	0.070	0.046	0.12	0.03	2	0.075	0.021	0.09	0.06	6	0.072	0.030	0.12	0.03	1	0.18	--	0.18	0.18	1	0.12	--	0.12	0.12

Table 2.3-17 (Continued)

			AG-6-1 (LOWER)					AG-6-2 (UPPER)					AG-4					HELL'S HOLE CANYON-1 (LOWER)					HELL'S HOLE CANYON-2 (UPPER)				
Parameters			No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.	No. of Samples	Mean	Stan. Dev.	Max.	Min.
MICRONUTRIENTS	Boron	(ug/l)	10	544	279	1300	250	5	366	48	440	320	7	2014	1319	3700	540	5	1800	224	1900	1400	5	1760	313	1900	1200
	Copper	(ug/l)	4	10	7	18	3	0	--	--	--	--	5	18	7	30	12	0	--	--	--	--	0	--	--	--	--
	Iron	(ug/l)	5	28	11	40	20	0	--	--	--	--	6	32	23	70	10	1	90	--	90	90	1	100	--	100	100
	Manganese	(ug/l)	5	2120	377	2500	1500	0	--	--	--	--	6	13	8	30	10	1	0	--	0	0	1	10	--	10	10
	Zinc	(ug/l)	4	3700	949	4600	2500	0	--	--	--	--	5	16	15	40	0	0	--	--	--	--	0	--	--	--	--
	Molybdenum	(ug/l)	4	3	4	7	0	0	--	--	--	--	5	426	123	530	230	0	--	--	--	--	0	--	--	--	--
	Silica	(mg/l)	10	19.9	1.0	21	18	5	19.2	1.1	21	18	7	12.9	0.7	14	12	5	10.3	0.7	11	9.7	5	9.1	0.7	10	8.3
TRACE METALS	Aluminum	(ug/l)	4	20	8	30	10	0	--	--	--	--	5	32	18	50	10	0	--	--	--	--	0	--	--	--	--
	Barium	(ug/l)	4	100	200	400	0	0	--	--	--	--	5	40	55	100	0	0	--	--	--	--	0	--	--	--	--
	Cadmium	(ug/l)	4	1.8	1.7	4	0	0	--	--	--	--	5	0.6	0.9	2	0	0	--	--	--	--	0	--	--	--	--
	Total Chromium	(ug/l)	4	158	112	320	70	0	--	--	--	--	5	34	21	60	10	0	--	--	--	--	0	--	--	--	--
	Lead	(ug/l)	4	3.3	4.0	9	0	0	--	--	--	--	5	2.0	3.5	8	0	0	--	--	--	--	0	--	--	--	--
	Lithium	(ug/l)	4	40	0	40	40	0	--	--	--	--	5	174	37	230	140	0	--	--	--	--	0	--	--	--	--
	Mercury	(ug/l)	4	0.28	0.21	0.5	0.0	0	--	--	--	--	5	0.24	0.29	0.7	0.0	0	--	--	--	--	0	--	--	--	--
	Selenium	(ug/l)	4	38	15	55	18	0	--	--	--	--	5	5.8	5.1	11	0	0	--	--	--	--	0	--	--	--	--
	Vanadium	(ug/l)	4	4.3	1.2	5.4	2.8	0	--	--	--	--	5	8.0	3.4	13	3.9	0	--	--	--	--	0	--	--	--	--
TRACE NON-METALS	Arsenic	(ug/l)	4	1.3	1.0	2	0	0	--	--	--	--	5	7.8	2.2	11	5	0	--	--	--	--	0	--	--	--	--
	Cyanide	(mg/l)	4	0.00	0.00	0.00	0.00	0	--	--	--	--	5	0.002	0.004	0.01	0.00	0	--	--	--	--	0	--	--	--	--
	Phenols	(ug/l)	1	1	--	1	1	0	--	--	--	--	1	1	--	1	1	0	--	--	--	--	0	--	--	--	--
	Pesticides	(ug/l)	0	--	--	--	--	0	--	--	--	--	1	0	--	0	0	0	--	--	--	--	0	--	--	--	--
	Herbicides	(ug/l)	0	--	--	--	--	0	--	--	--	--	1	0	--	0	0	0	--	--	--	--	0	--	--	--	--
RADIOACTIVE CONST.	Gross Alpha as U-nat.	(ug/l)	0	--	--	--	--	0	--	--	--	--	1	<50	--	<50	<50	0	--	--	--	--	0	--	--	--	--
	Gross Beta as Sr 90	(pCi/l)	0	--	--	--	--	0	--	--	--	--	1	5.3	--	5.3	5.3	0	--	--	--	--	0	--	--	--	--
	Gross Beta as Ce 137	(pCi/l)	0	--	--	--	--	0	--	--	--	--	1	6.4	--	6.4	6.4	0	--	--	--	--	0	--	--	--	--
	Potassium 40	(pCi/l)	0	--	--	--	--	0	--	--	--	--	1	1.3	--	1.3	1.3	0	--	--	--	--	0	--	--	--	--
	Radium 226, radon method	(pCi/l)	0	--	--	--	--	0	--	--	--	--	1	0.09	--	0.09	0.09	0	--	--	--	--	0	--	--	--	--
	Diss. Uranium, dir. fluorometric	(ug/l)	0	--	--	--	--	0	--	--	--	--	1	15	--	15	15	0	--	--	--	--	0	--	--	--	--

Table 2.3-18

SUMMARY OF ALLUVIAL WATER QUALITY FOR SOUTHAM CANYON (AG-6),
SEPTEMBER 21, 1979

Parameters		AG-6-1 (Lower)	AG-6-2 (Upper)
GENERAL CHARACTERISTICS	Total Alkalinity as CaCO ₃ (mg/l)	320	320
	Dissolved Solids (mg/l)	1,200	924
	Total Hardness as CaCO ₃ (mg/l)	320	250
	Noncarbonate Hardness as CaCO ₃ (mg/l)	4	0
	pH (units)	8.2	8.2
	Specific Conductance at 25°C (umhos/cm)	1,650	1,260
	Temperature (°C)	14.5	14.0
MAJOR CATIONS	Calcium, dissolved (mg/l)	70	50
	Magnesium, dissolved (mg/l)	36	31
	Potassium, dissolved (mg/l)	2.8	2.9
	Sodium, dissolved (mg/l)	260	210
	Sodium Adsorption Ratio	6.3	5.8
	Percent Sodium	76	64
	Strontium, dissolved (ug/l)	1,200	1,200
MAJOR ANIONS	Chloride, dissolved (mg/l)	45	41
	Sulfate, dissolved (mg/l)	570	370
	Sulfide as S, total (mg/l)	0.0	3.2
	Fluoride, dissolved (mg/l)	0.2	0.2
	Bromide, dissolved (mg/l)	0.4	1.2
BIO CHEM CONST	Chemical Oxygen Demand (mg/l)	--	640
	Organic Carbon, dissolved (mg/l)	7.3	6.4
MACRO NUTRIENTS	Ammonia as N, dissolved (mg/l)	0.00	0.00
	Nitrite plus Nitrate as N, dissolved (mg/l)	0.06	0.17
	Ammonia plus Organic Nitrogen as N, total (mg/l)	0.84	2.8
	Ortho-Phosphorus as P, dissolved (mg/l)	0.07	0.02
	Phosphorus as P, total (mg/l)	0.59	3.7
MICRO NUTRIENTS	Boron, dissolved (ug/l)	260	230
	Copper, dissolved (ug/l)	33	14
	Iron, dissolved (ug/l)	70	360
	Manganese, dissolved (ug/l)	290	210
	Zinc, dissolved (ug/l)	340	190
	Molybdenum, dissolved (ug/l)	12	16
	Silica as SiO ₂ , dissolved (mg/l)	20	22
TRACE METALS	Aluminum, dissolved (ug/l)	30	140
	Barium, dissolved (ug/l)	30	80
	Cadmium, dissolved (ug/l)	1	< 1
	Chromium, dissolved (ug/l)	10	10
	Lead, dissolved (ug/l)	< 10	< 10
	Lithium, dissolved (ug/l)	20	10
	Mercury, dissolved (ug/l)	0.0	0.1
	Selenium, dissolved (ug/l)	2	2
	Vanadium, dissolved (ug/l)	3	11
TRACE NON METALS	Arsenic, dissolved (ug/l)	3	4
	Phenols (ug/l)	5	4

groundwater, which is used mostly for stock watering and alternate domestic supplies (Ref. 2-15). The American Gilsonite Company has drilled wells in the alluvium of the White River south of Bonanza, Utah. The wells supply water for the Gilsonite mining operation and for the residents of Bonanza. A few deep wells located in Asphalt Wash, which produce water from the Douglas Creek Member, are used for stock watering. Overall, the aquifers on the tracts do not contain sufficient quantities of water to sustain project requirements for a long period of time.

2.4 AIR RESOURCES

This section describes the climatology, meteorology, air quality, radiation, and ambient sound levels on Tracts Ua and Ub. These data were measured over the period from 1975 to 1979 at the sites shown in Figure 2.4-1. The most intensive measurement program took place during the first two years, or "baseline" period, and included meteorological measurements at all sites except A13, air quality measurements at most sites, and three sound surveys. During the other three years, meteorological measurements were made only at Sites A4, A6, A11, and A13, and air quality measurements continued only at Site A6. Some limited radiation measurements continued into 1979.

2.4.1 CLIMATOLOGY

Climatological data include pressure, precipitation, evaporation, temperature, relative humidity, and heat flux. The horizontal transport of an air mass is a consequence of large-scale differences in air pressure. The determining factor in Utah's weather during the winter months is the Intermountain Region High-Pressure Cell (Basin High). Figure 2.4-2 shows this high-pressure area in January, and compares it with the weather pattern in July, when the pressure decreases. In January, storm tracks tend to pass north of the high-pressure area through Montana, and south of it through southern Utah. After February, storm tracks become more prevalent over northern Utah as the strength of the Basin High wanes. During the spring months, the weakening of the high pressure allows higher precipitation in northern Utah. During the summer months, the pressure is lower and sporadic moisture from the Gulf of Mexico brings periods of scattered thundershower activity. Beginning in September, the storm fronts from the north increase, but are interspersed with many periods of clear weather whenever high pressure builds up in the Intermountain Region.

Parameters that contribute to this climatological picture are discussed below.

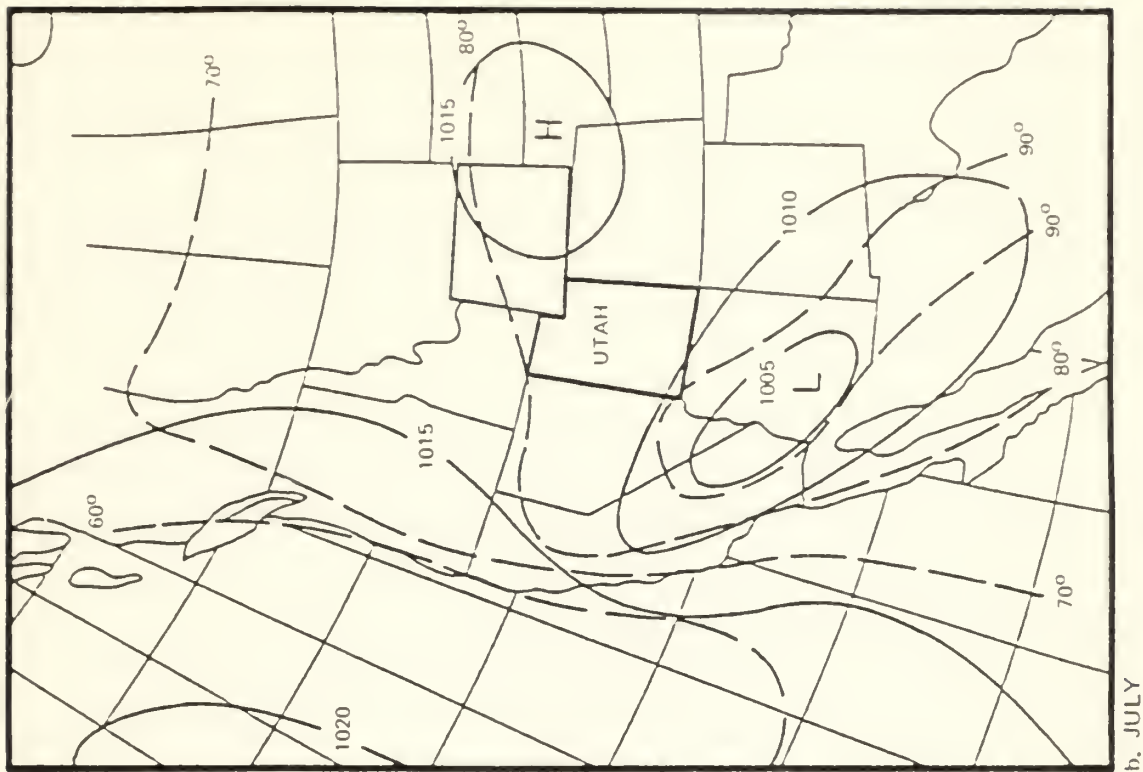
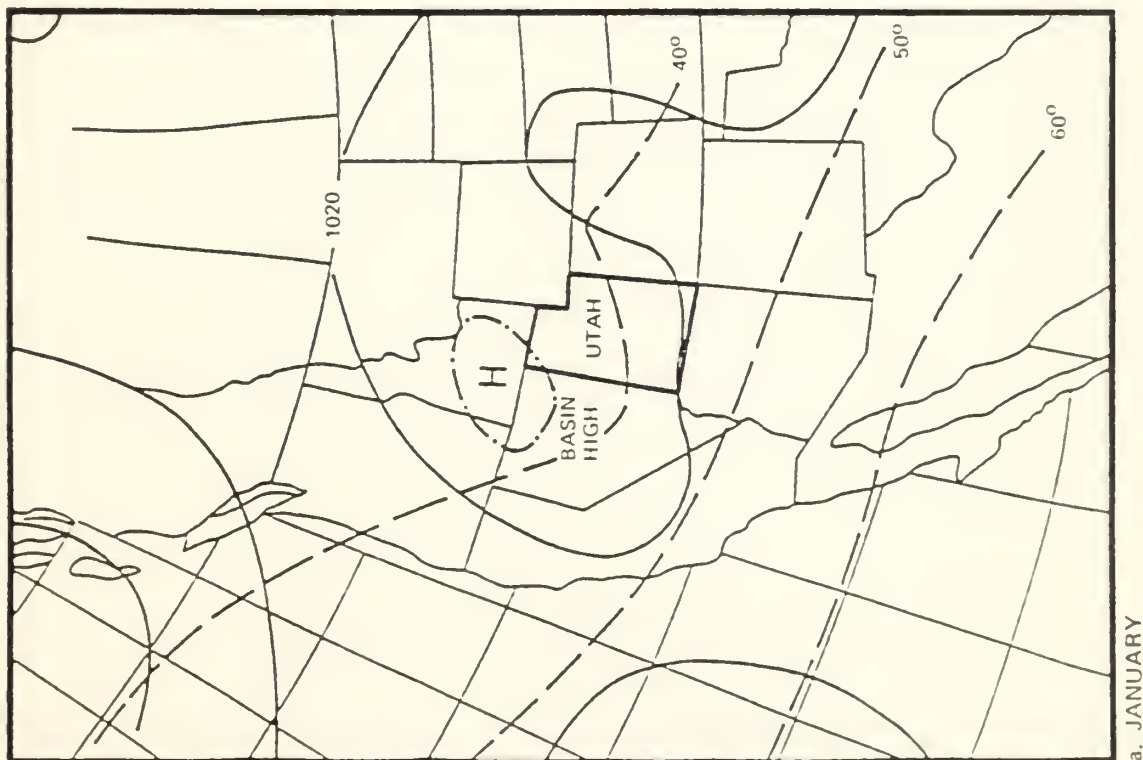


Figure 2.4-2 NORMAL SEA LEVEL PRESSURE (MB) AND TEMPERATURE (°F) IN JANUARY AND JULY

Source: U.S. Weather Bureau, 1952.

2.4.1.1 Barometric Pressure

Barometric pressure is an indicator of the position and intensity of major weather systems passing over the tracts. Both the highest and lowest values of pressure generally occur from October to April in conjunction with the passage of winter storms and the presence of the Basin High. During the summer, the air mass systems are much weaker and, consequently, the pressure shows less fluctuation.

The pressure on the tracts from 1975 to 1979 averaged 24.84 inches (631 mm) of Hg. The highest pressure was 25.43 inches (646 mm) of Hg in November 1975, and the lowest was 24.17 inches (614 mm) during March 1975 and 1977.

2.4.1.2 Precipitation and Evaporation

Precipitation. A network of precipitation gauges was established on or near Tracts Ua and Ub to monitor annual precipitation. The network was first established in the last quarter of 1974, and ranged from a low of 2 gauges to a high of 13 gauges that were operated throughout the year.

From data collected thus far, two major factors appear to account for the variations in annual precipitation amounts from station to station. The primary factor is the variation in terrain. In general, monitoring indicated that precipitation was heavier on ridgetops and lighter in valleys. It has been determined that this orographic effect will produce approximately a 3-inch increase in precipitation per 1,000 foot increase in elevation. The annual average precipitation ranged from a high of 10.90 inches (27.69 cm) for the highest station to a low of 8.36 inches (21.13 cm) for the lowest station.*

The second factor is the slow-moving, intense, isolated thunderstorms that cross the tracts. The effects of these storms may override the orographic effects at some stations, giving the data a uniform appearance.

*The annual average precipitation values were determined for 8 gauge locations for the water years 1975-79. The missing records were estimated based on the data collected at the other locations and on topographic relationships.

Historical data from Bonanza, Utah, near the northern edge of Tracts Ua and Ub show that Bonanza has an average precipitation of 8.0 inches (20.3 cm), while Tracts Ua and Ub have an annual average of approximately 9.0 inches (22.9 cm).

Evaporation. Evaporation from ground pans was measured in Southam Canyon (Site A2) from 1975 through 1979 and on a ridge above Evacuation Creek (Site A6) during 1975 and 1976. This second station was moved (prior to the 1977 season) to the proposed plant site (Site A13) and collected data through 1979.

Evaporation data collected for the freeze-free period, approximately May through September, indicated an average total pan evaporation of approximately 37 inches (94 cm) for the Southam Canyon location. The data collected to date have not conclusively defined variations of evaporation throughout the tracts. It is apparent that pan evaporation rates at various locations depend on elevation, wind run, and other factors.

2.4.1.3 Temperature

Temperature was also measured at several locations on the tracts. These locations varied from seven during the first year to four during the last three. Some spatial variations, generally attributable to topography, were evident from these data. Site A10 (operational only in the first two years) consistently registered a lower temperature than the others because it was in a protected valley just north of Tract Ua along the White River.

Site A6 was the location of a 100-foot (30 m) tower that recorded temperatures at three levels. Figure 2.4-3 shows the average diurnal variation in temperature for January and July for the 33-foot (10 m) level at this site during the five-year period. Minimum temperatures were usually recorded during January, with the maximums generally in July.

The diurnal variation shown in this figure is very similar to that observed in other months and at other sites. The daily maximum temperature was generally measured between 1400 and 1500 hrs MST, while the minimum was usually between 0400 and 0500 hrs MST.

Monthly average temperatures for the same site and period are shown in Figure 2.4-4. Average monthly minimums and maximums are also shown. Temperatures at this site varied from a low of -22F (-30C) during January 1979 to a high of 97F (36C) in July of 1976 and 1978 and August 1979. The average temperature for all years was 45F (8C).

2.4.1.4 Relative Humidity

Relative humidity was measured throughout the five-year period. In general, relative humidity is lower in summer than in the winter. The highest values were found in winter from 0400 through 0800 hrs and averaged above 80 percent. The lowest values occur from 1400 to 1700 hrs in the summer, with values of approximately 25 percent.

The diurnal variation of relative humidity is approximately the reciprocal of temperature, indicating that the amount of moisture in the air remains fairly constant during a typical day on the tracts. Figure 2.4-5 shows the average diurnal variation in relative humidity in January and July from 1975 to 1979. These values are fairly typical for each of the five years.

2.4.1.5 Heat Flux

Heat flux was determined on the tracts by measuring the net thermal radiation at Site A6. This parameter is the amount of heat received from the sun minus the amount lost by the earth during radiative cooling. This factor affects the stability of the atmosphere, and solar radiation influences the rate of various photochemical processes.

Figure 2.4-6 shows the average hourly net solar radiation on the tracts during January and July from 1975 to 1979. (January 1975 and July 1979 were not included because of instrument problems.) As should be expected, the solar radiation is higher in the summer due to longer days, more intense sunlight, and less cloudiness. Highest values during the day generally occurred between 1100 and 1200 hrs with a peak of 1.25 ly/min in June 1977.

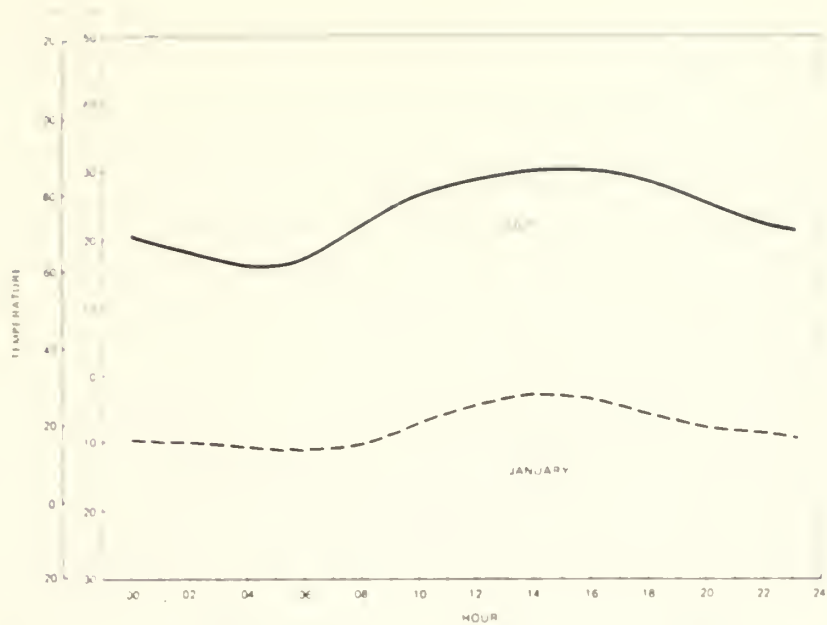


Figure 2.4-3 DIURNAL VARIATION OF MEAN HOURLY TEMPERATURES AT SITE A6 FROM 1975 TO 1979

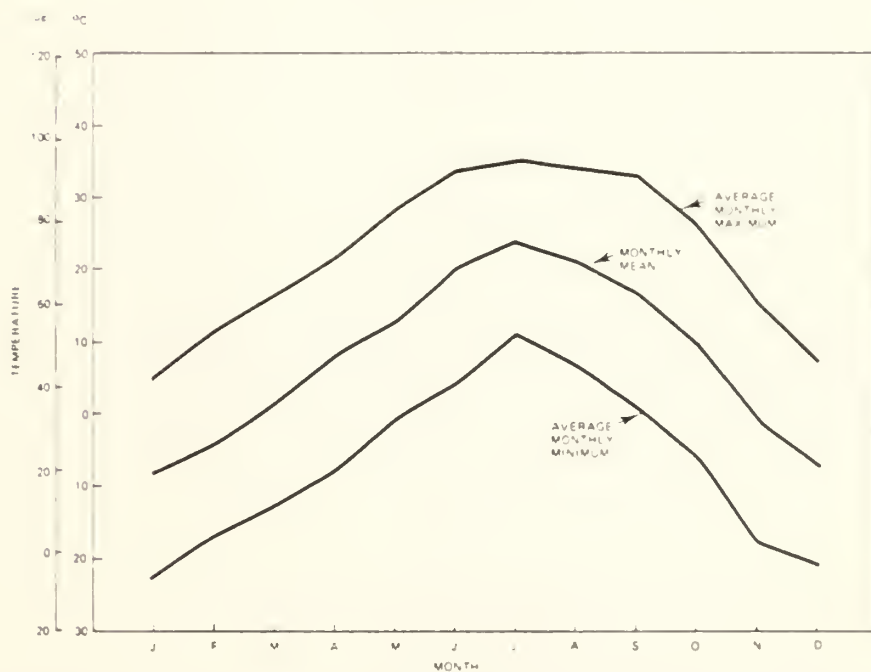


Figure 2.4-4 AVERAGE MONTHLY MAXIMUM AND MINIMUM AND MONTHLY MEAN TEMPERATURE AT SITE A6 FROM 1975 TO 1979

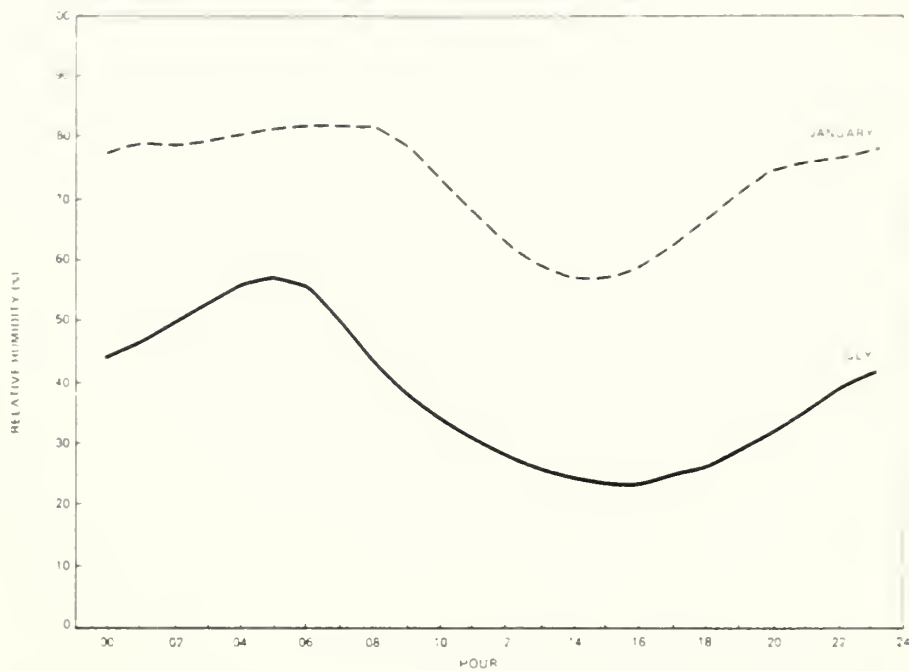


Figure 2.4-5 DIURNAL VARIATION OF MEAN RELATIVE HUMIDITY AT SITE A6 IN JANUARY AND JULY FROM 1975 TO 1979

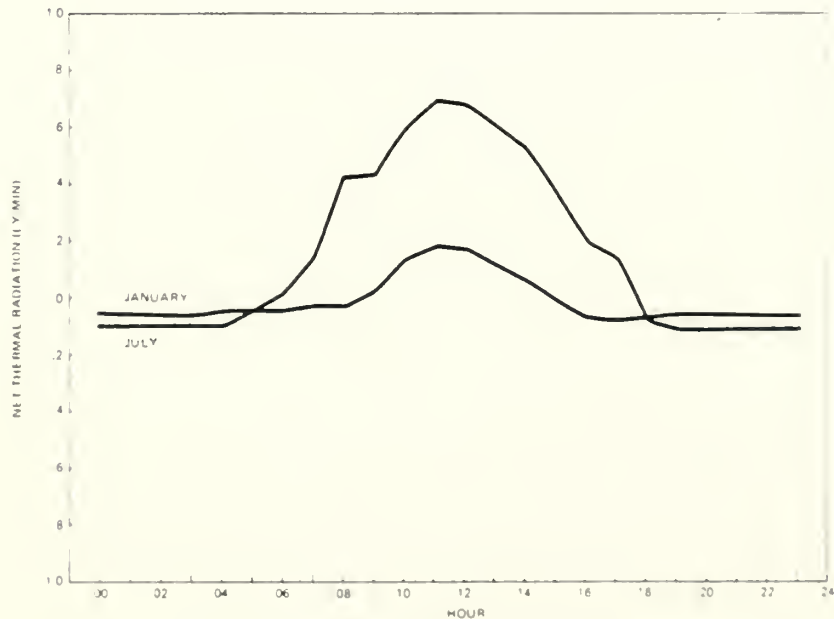


Figure 2.4-6 DIURNAL VARIATION OF MEAN NET THERMAL RADIATION AT SITE A6 IN JANUARY AND JULY FROM 1975 TO 1979

2.4.2 METEOROLOGY

Unlike climatology, which deals with general atmospheric conditions and averages over the long-term, meteorology is concerned with the specifics of motion in the atmosphere, and the diffusion of the materials in it. This section discusses meteorology in terms of surface flow, synoptic or upper air meteorology, and diffusivity.

2.4.2.1 Surface Flow

Surface winds were measured at 12 sites during the first year of the baseline period, 8 during the second year of the baseline period, and 4 during the last three years of the extended monitoring program. It was found that with the knowledge gained during the first two years, the meteorological flow could be adequately characterized from the remaining four sites. An examination of the seasonal wind roses for each of the years shows that the predominant wind directions are similar from year to year.

The rugged terrain features in the area complicate the airflow pattern. Table 2.4-1 lists the prevailing direction from which the wind blows and average speed by month for the four wind sites from 1975 to 1979. The table shows some spatial variation in wind speed on the tracts. Generally, nighttime drainage flow from higher elevations is prevalent throughout the year. Figure 2.4-7a shows the typical airflow streamlines for the early morning drainage pattern. The solid arrows are wind vectors at the monitoring sites, and the longer lines are estimated flow streamlines. The large open arrow depicts the mesoscale flow direction in the greater White River drainage basin. The drainage pattern did not deviate significantly throughout the five years. The drainage flow is always from higher to lower terrain.

Figure 2.4-7b shows an upslope airflow pattern that is transitional between drainage and synoptic flow. The surface-based inversion that results from strong nighttime radiative cooling begins to lose some of its strength

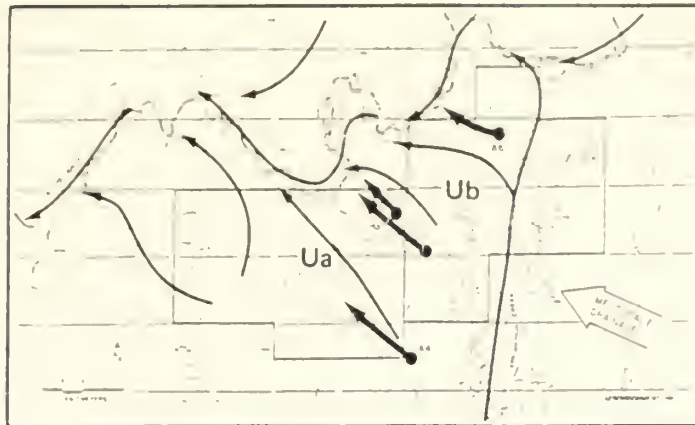
Table 2.4-1

AVERAGE MONTHLY WIND SPEEDS AND PREVAILING DIRECTION
ON TRACTS Ua AND Ub FROM 1975 TO 1979(a)

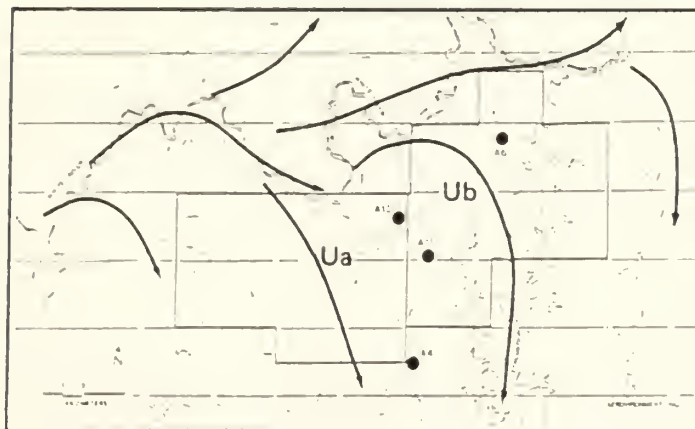
Month	Site A4		Site A6		Site A11		Site A13	
	Direction	Speed (mph)	Direction	Speed (mph)	Direction	Speed (mph)	Direction	Speed (mph)
January	W	4.5	WSW	4.3	VAR	4.3	W	2.7
February	W	5.1	WSW	5.4	NW	5.1	W	2.9
March	W	6.7	ESE	7.2	SE	6.7	W	4.7
April	W	7.8	SE	8.7	SE	7.8	VAR	5.8
May	W	7.8	SE	9.4	SE	8.1	SE	6.3
June	SW	8.5	ESE	9.8	SE	8.5	WNW	6.9
July	WNW	7.2	ESE	7.8	SE	7.6	SE	5.8
August	WNW	7.4	ESE	8.1	SE	7.8	SE	6.3
September	WNW	6.7	ESE	7.4	SE	7.4	SE	5.4
October	WNW	5.8	ESE	6.7	SE	6.3	SE	4.0
November	W	5.1	ESE	5.8	VAR	5.4	VAR	3.8
December	W	5.4	ESE	4.9	VAR	4.7	ESE	3.4
Annual	W	6.5	ESE	7.2	SE	6.7	SE	4.9

(a) Direction from which the wind comes:

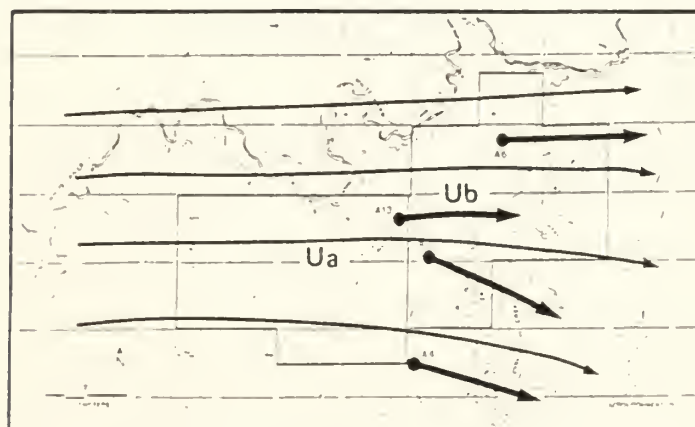
W = west
S = south
N = north
E = east
VAR = variable



a. DRAINAGE FLOW DURING EARLY MORNING HOURS



b. TRANSITIONAL FLOW



c. AFTERNOON SYNOPTIC FLOW

5 MPH
 WIND VECTOR
 STREAMLINE

Figure 2.4-7 TYPICAL AIR FLOW PATTERNS ON TRACTS Ua AND Ub FROM 1975 TO 1979

snortly after sunrise. As the morning progresses, the heat gained by the surface from solar radiation exceeds that lost by terrestrial radiation to the sky, and the soil temperature rises, warming the air above. This creates a pressure difference resulting in upslope flow. This pattern is transitional and generally lasts less than an hour, but it is important to the understanding of dispersion of pollutants since plume fumigation (mixing of an elevated plume to the ground) would occur under this condition. Because of its brevity, this pattern is lost in hourly average wind direction tabulation. This pattern begins earlier during the summer months than during the winter when the sun rises later.

Figure 2.4-7c shows afternoon airflow patterns. Very little directional difference is noted from site to site, but the average speeds are higher during the summer. This is the average synoptically induced westerly flow that is encountered in this portion of Utah throughout the year.

Figure 2.4-8 displays the five-year average hourly wind speeds for January and July. The January speeds are practically the same throughout the day. The wind speeds between 0800 and 1200 hrs MST are only slightly lower than during the rest of the day. The July wind speeds generally reach an average peak of about 11 mph between 1400 and 1800 hrs MST.

An indication of wind speed changes throughout the year is depicted on Figure 2.4-9, which shows the monthly average wind speeds and standard deviations, along with the peak wind speed for each month at Site A6. The average wind speeds increase through spring and decrease thereafter. The peak wind during 1975 through 1979 of 42.5 mph occurred during June 1976.

Figure 2.4-10 shows the directional wind roses at the eight monitoring stations on the tracts for the middle month of the four seasons (January, April, July, and October). Although individual months may show different prevailing directions, winds from the east-southeast have been the most prevailing direction at Site A6 throughout the period, which is a direct result of the drainage flow that exists at this site.

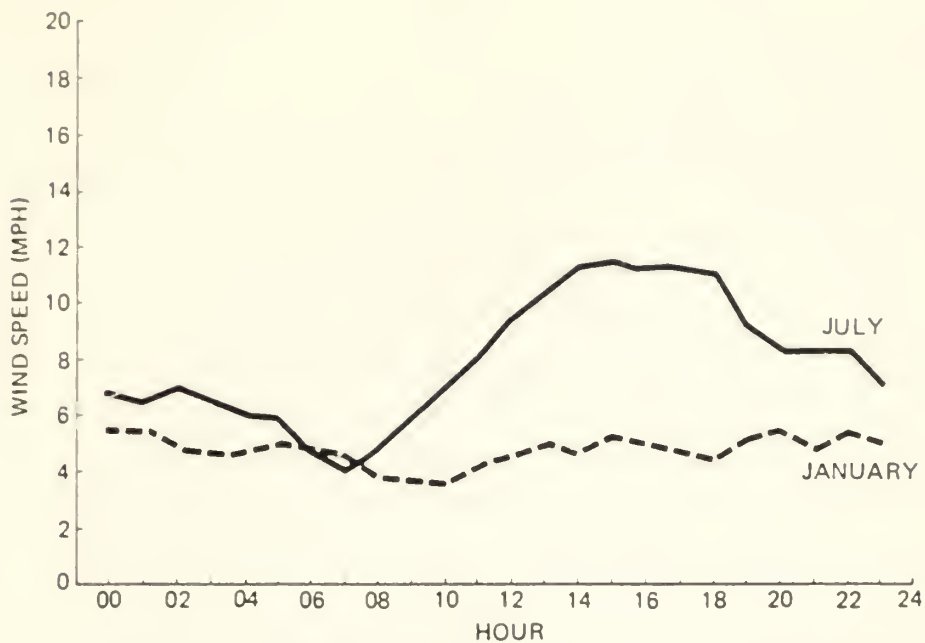


Figure 2.4-8. DIURNAL VARIATION OF MEAN WIND SPEED AT SITE A6 IN JANUARY AND JULY FROM 1975 TO 1979

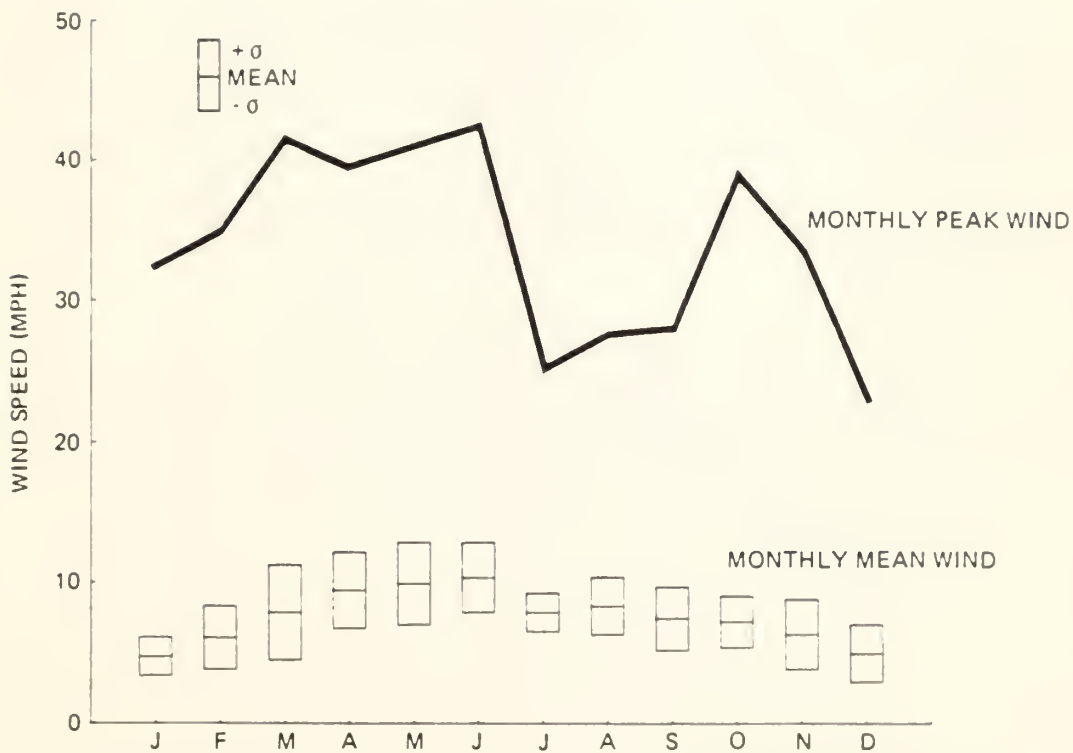


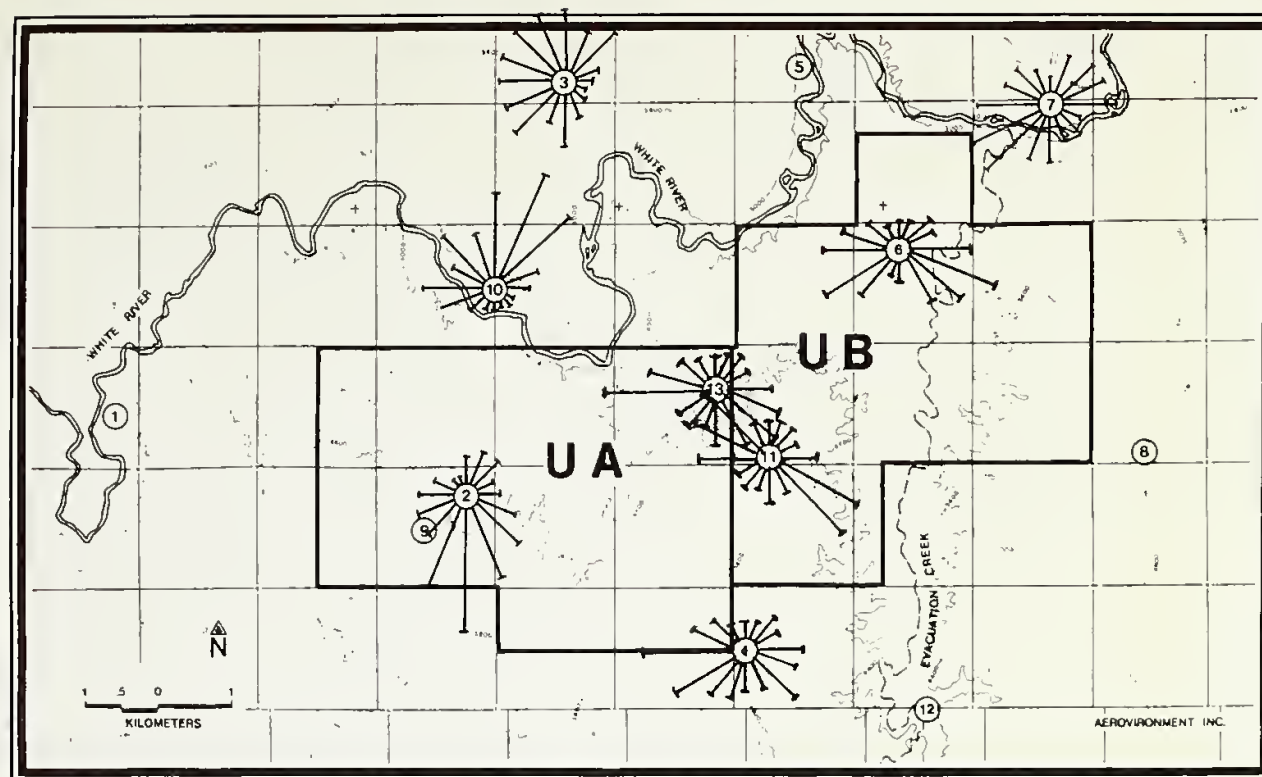
Figure 2.4-9 MONTHLY MEAN AND PEAK WINDS SPEEDS AND THEIR STANDARD DEVIATIONS AT SITE A6 FROM 1975 TO 1979

2.4.2.2 Upper Air Meteorology

Measurements of the upper air meteorology were made only during the first year (1974-1975) on the tracts. These measurements included rawinsonde balloon launches twice daily on every sixth day, and continuous acoustic sounding at Site A6. The rawinsonde provided records of temperature, relative humidity, and wind from the surface to 500 millibars (about 18,000 feet above mean sea level). A monostatic acoustic sounder displayed atmospheric structure (mixing height, stability, thermal plumes) up to about a half-mile (one kilometer) above the surface. Additional bistatic records taken on a less regular basis were used to show atmospheric turbulence between 650 feet (200 m) and 1,500 feet (450 m) above ground level.

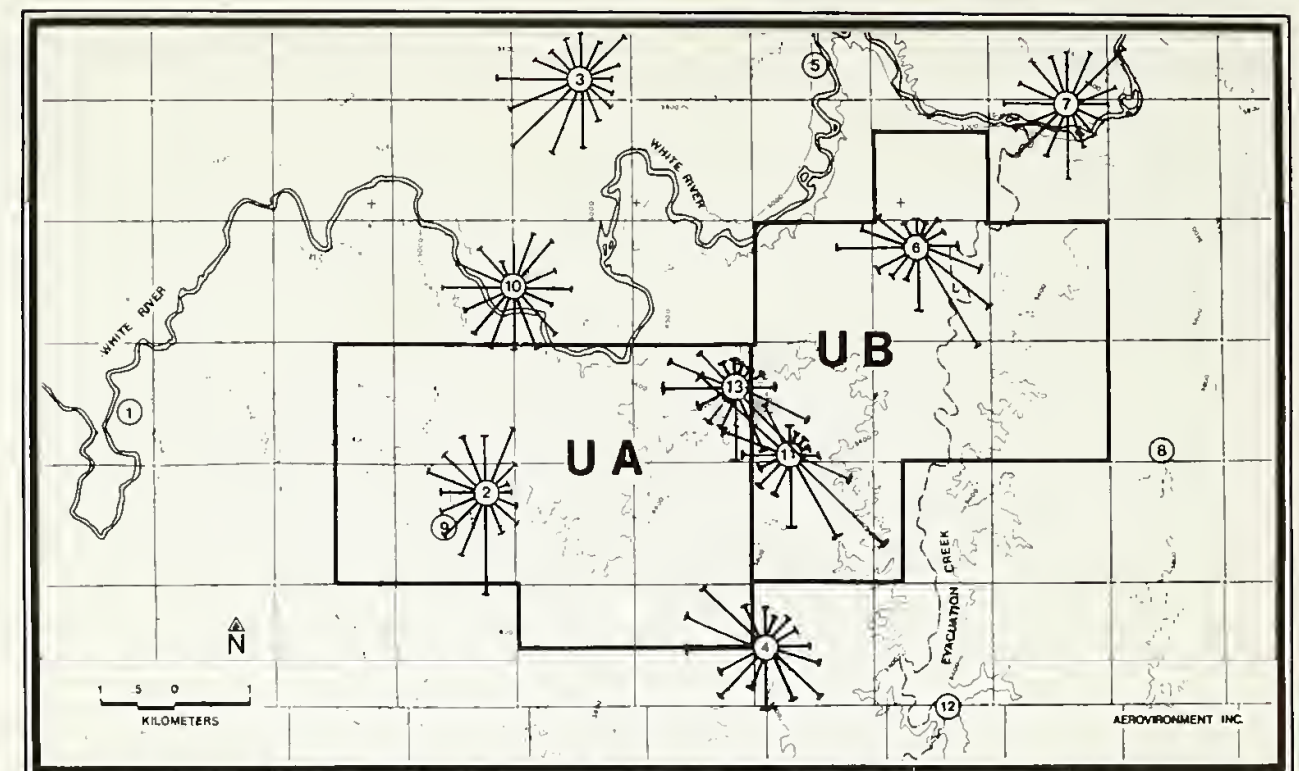
From January 1975 through January 1976, surface-based inversions attributable to nocturnal cooling of the earth's surface were generally observed in the morning 94 percent of the time, and usually disappeared in the afternoon. The average thickness of the morning inversion changed from about 1,700 feet (517 m) in winter to 912 feet (278 m) in spring to 1,190 feet (362 m) in summer and to 1,590 feet (484 m) in fall. The strength of the inversion in spring and summer was about 0.8F per 100 feet (1.5C/100 m). The strength of the inversion in fall and winter was stronger with an average of 1.0F per 100 feet (3.1C/100 m) and 0.9F per 100 feet (0.9C/100 m), respectively.

Upper-air inversions were frequently detected. These inversions were associated with anticyclones that are common in fall and winter, and were indicated in 53 percent of all morning soundings and 87 percent of all afternoon soundings. The average thickness of the morning upper-air inversions was 830 feet (252 m), with an average strength of 0.2F per 100 feet (0.7C/100 m). The height of the base of the morning elevated inversions was 540 feet (165 m) above ground level. The average base of the afternoon elevated inversions was higher at about 3,050 feet (930 m). The afternoon inversions had an average thickness of 938 feet (286 m) with an average strength of 0.3F per 100 feet (3.0C/100 m).



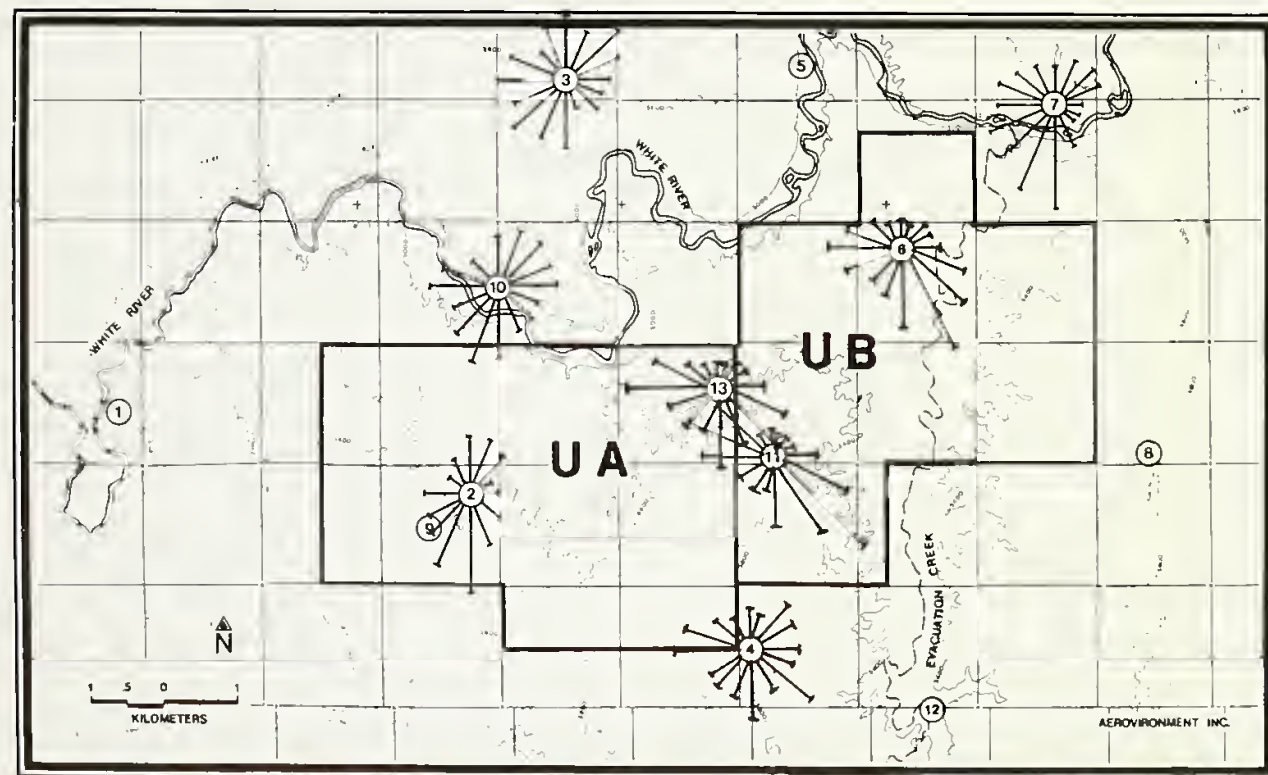
A. JANUARY

0 25%



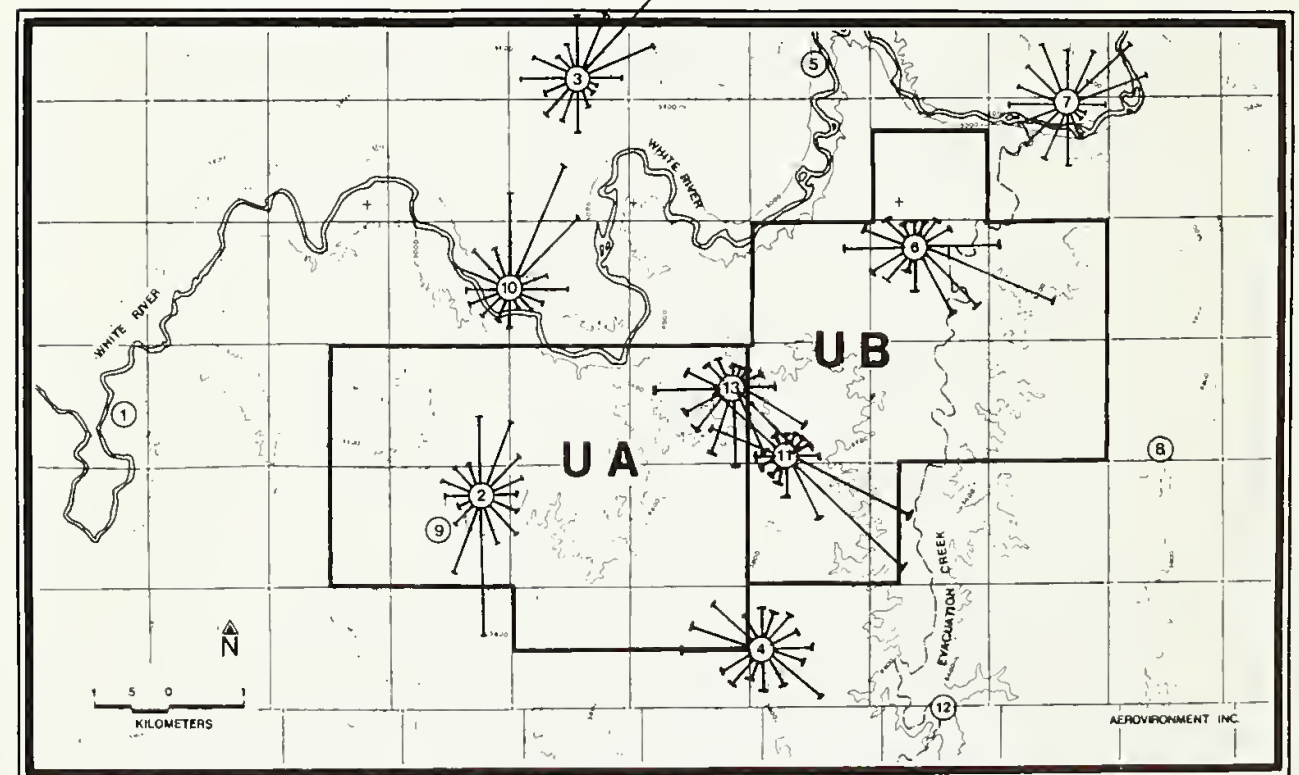
C. JULY

0 25%



B. APRIL

0 25%



D. OCTOBER

0 25%

Figure 2.4-10 DIRECTIONAL WIND ROSES
(THE LENGTH OF EACH BAR REPRESENTS
THE FREQUENCY OF WINDS FROM THE
DIRECTION TOWARD WHICH THE BAR POINTS.)

The temperatures measured above the inversions were generally adiabatic and remained almost invariant throughout the day.

Relative humidity in the lower half-mile (one kilometer) above the ground was about 65 percent in the morning and about 50 percent in the afternoon, with no significant change from February to April. In July, this value decreased to about 45 percent in the morning and to about 30 percent in the afternoon. In October, it was about 40 percent in the morning and about 30 percent in the afternoon.

In the upper levels, relative humidity was generally slightly higher for both the morning and afternoon than near the surface. For instance, winter morning and afternoon levels increased to around 80 and 70 percent, respectively, and summer levels to around 50 and 40 percent, respectively.

In the first half-mile above the ground, the winds were quite variable from day to day. Above this level, winds were usually stronger and from the west, with an average speed of about 17.9 mph during the winter and spring quarters and about 8.9 mph in the summer and fall.

Inversions have considerable variation and are site-specific in rugged terrain. The long-term upper air climatology that is closest to that of Tracts Ua and Ub is at Grand Junction, Colorado. These data were used to assess the normality of the period of upper-air measurement because synoptic-scale air mass characteristics are similar. This assessment was done by comparing the Grand Junction 700 millibar level data collected in 1975-76 with 10-year averages. Since the onsite data set did not vary significantly from the long-term averages, it was assumed that the measurement period was fairly representative. Therefore, continued measurement of these parameters at the tracts was not necessary.

2.4.2.3 Diffusivity

When a gaseous emission in the form of a plume or puff is released into the atmosphere, it is transported by the prevailing wind. As it travels downwind, its concentration decreases as it diffuses into the surrounding air. The growth of the volume occupied by the emission is determined by the strength of the turbulence in the air. That strength in the vertical direction is governed mainly by the atmospheric stability, while in the horizontal direction it depends upon both stability and mechanical generation of turbulence. Mechanical turbulence is defined as irregular airflow induced by surface roughness.

A number of parameters related to diffusivity were measured on the tracts from 1975 to 1979. Besides wind speed and direction, these parameters are σ_θ , a measure of the lateral turbulence; σ_w , vertical turbulence fluctuation; and ΔT , the temperature difference between two levels. The first two variables, σ_θ and σ_w , were measured at three sites during the first two years, and at two sites during the last three years. ΔT was measured between 33 and 100 feet (10 and 30 m) at two sites during the first two years, and at one for the last three. In addition, special diffusion experiments were performed in February and June 1975 in which smoke plumes were released from 300 feet (90 m), and actual diffusion measured by aircraft probing.

Using σ_θ data at Site A6, the frequency distribution of different "diffusion" classes (often called "stability" classes) was computed and is presented in Table 2.4-2. For each of the years, diffusion Classes D and E were the most prevalent on the tracts.

A complete dispersion picture must also include the effect of plume rise. The meteorological parameters that most greatly influence the height of a plume are atmospheric stability and wind speed. Vertical atmospheric stability can be best defined by ΔT data. Figure 2.4-11 presents the average diurnal variation of ΔT at Site A6 during January and July from 1977 to 1979.

Table 2.4-2

RELATIVE FREQUENCY DISTRIBUTION OF DIFFUSION CLASSES AT SITE A6
FROM JUNE 1975 THROUGH DECEMBER 1979(a)

Season	Diffusion Classes ^(b)						Total Number of Observations
	Unstable			Neutral	Slightly Stable	Very Stable	
	A	B	C	D	E	F	
Winter	0.4	1.3	6.7	27.6	48.9	15.1	8,378
Spring	0.4	2.2	10.1	29.8	50.2	8.3	8,829
Summer	0.8	3.1	12.2	37.2	41.3	5.4	10,239
Fall	0.5	1.7	10.3	32.3	40.9	14.3	10,294

(a) σ_e used to define class.

(b) Basis: Atomic Energy Commission, Safety Guides for Water-Cooled Nuclear Power Plants, NRC Regulatory Guide 1.23, 1972.

Stable or slightly stable atmospheric conditions prevailed in early morning and evening hours during January and July, with stability lasting into the late morning in January. In the afternoon, neutral or unstable conditions were a general rule.

Table 2.4-3 gives the frequency distribution of stabilities from 1977 to 1979 based on ΔT . The table shows that unstable or neutral conditions are the most frequent conditions during all seasons, especially spring. Very stable conditions occurred least often during spring and more often in the fall and winter. The accuracy of the ΔT system used at Site A6 during the last three years differed from that used during the first two years. The new system measures ΔT to within $\pm 0.18^\circ\text{F}$ ($\pm 0.1^\circ\text{C}$) over the measurement interval of 66 feet (20 m). Accuracy was below this level in the initial years, so no comparison of the ΔT data was attempted for these two periods.

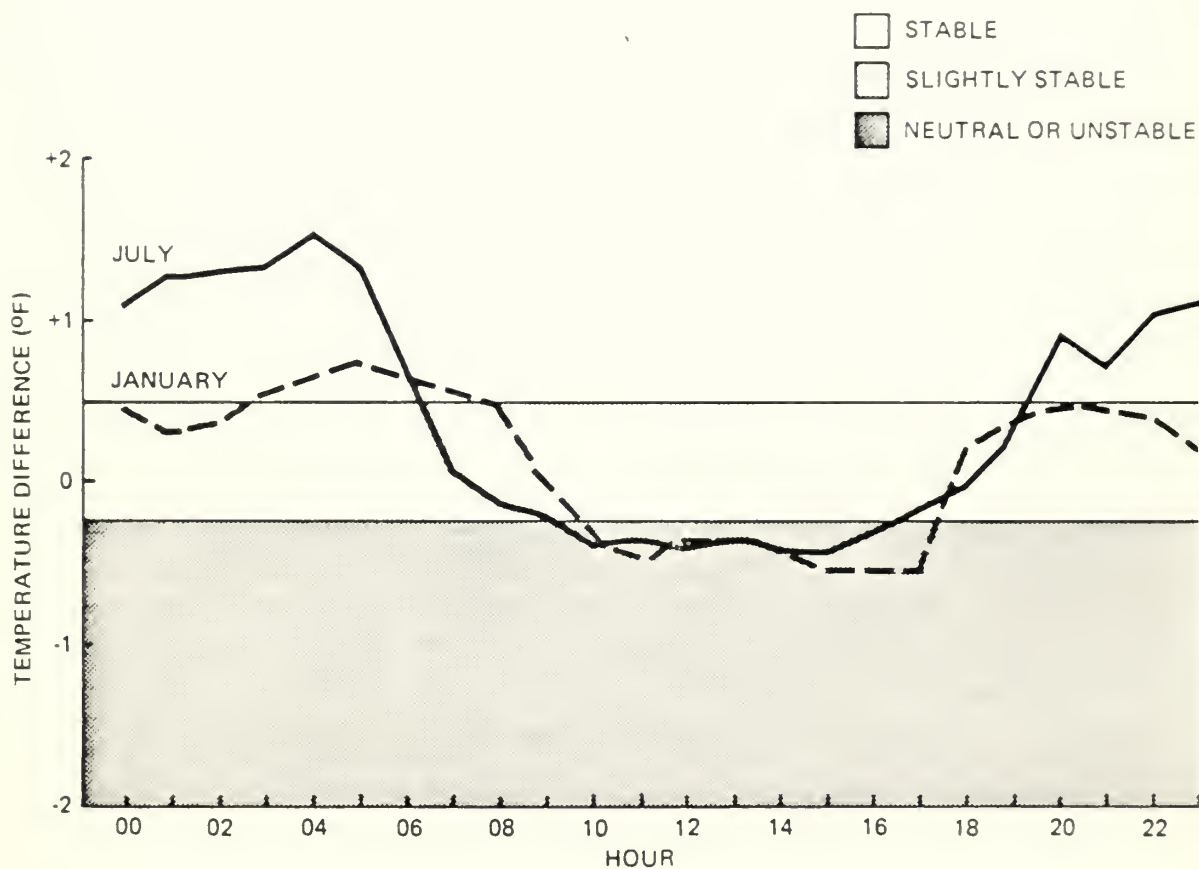


Figure 2.4-11 DIURNAL VARIATION OF THE MEAN ΔT AT SITE A6
IN JANUARY AND JULY FROM 1977 TO 1979

Table 2.4-3

PERCENT FREQUENCY DISTRIBUTION OF STABILITY BY SEASON
AT SITE A6 FROM 1977 TO 1979

Season	Stability (ΔT in F/1,000 ft)			Total Number of Observations
	Unstable or Neutral (<-2.74)	Slightly Stable (-2.74 to 8.22)	Very Stable (>8.22)	
Winter	41.3	21.3	37.3	6,404
Spring	46.3	28.0	25.7	6,210
Summer	37.7	26.3	36.3	6,542
Fall	43.3	18.0	38.7	6,552
All Year	42.1	23.4	34.5	25,708

In general, the diffusion in the canyons (represented by Site A2) during adverse mixing conditions (low winds, low inversion heights) is less than in the more open, rolling country (Site A6). The low diffusion conditions occurred more frequently during the winter than during the other three seasons in the first three years, but increased winter storminess in the last two years reduced these occurrences. During 1978 and 1979, low diffusivity occurred most frequently during the summer months (about 40 percent of the time).

2.4.3 AIR QUALITY

Factors that reduce the quality of the air include gaseous and particulate air contaminants. Standards, referred to as the National Ambient Air Quality Standards (NAAQS) have been developed for a number of pollutants to protect health and welfare. These standards, which have been adapted by the State of Utah, are given in Table 2.4-4.

Table 2.4-4

NATIONAL AMBIENT AIR QUALITY STANDARDS FOR CRITERIA POLLUTANTS^(a)

Pollutant	Averaging Time	Primary Standards ^(c)	Secondary Standards
Ozone (O ₃)	1 hour	235 $\mu\text{g}/\text{m}^3$ (0.12 ppm)	Same as primary
Carbon Monoxide	8 hour ^(b)	10 mg/m^3 (9 ppm)	Same as primary
	1 hour ^(b)	40 mg/m^3 (35 ppm)	Same as primary
Sulfur Dioxide (SO ₂)	annual	80 $\mu\text{g}/\text{m}^3$ (0.03 ppm)	—
	24 hour ^(b)	365 $\mu\text{g}/\text{m}^3$ (0.14 ppm)	—
	3 hour ^(b)	—	1,300 $\mu\text{g}/\text{m}^3$ (0.5 ppm)
Nitrogen Dioxide (NO ₂)	Annual average	100 $\mu\text{g}/\text{m}^3$ (0.05 ppm)	Same as primary
Hydrocarbons ^(d) (Corrected for Methane — NMHC)	3 hour (6-9 AM)	160 $\mu\text{g}/\text{m}^3$ (0.24 ppm)	Same as primary
Suspended Particulate Matter	Annual geometric mean	75 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$
	24 hour ^(b)	260 $\mu\text{g}/\text{m}^3$	150 $\mu\text{g}/\text{m}^3$
Lead	Maximum arithmetic mean averaged over a calendar quarter	1.5 $\mu\text{g}/\text{m}^3$	Same as primary standards

(a) State standards for Utah are the same.

(b) Not to be exceeded more than once a year.

(c) Concentration is expressed first in the units in which it was promulgated. Equivalent units given in parentheses are based on a reference temperature of 25C and a reference pressure of 760 mm of Hg. All measurements of air quality are to be corrected to these references. In this table, ppm refers to ppm by volume, or micromoles of pollutant per mole of gas.

(d) Guideline value.

Other values, such as aesthetics, can also be important. The main effect air contaminants have on aesthetics is in their impact on visibility. Although no standards currently exist in Utah for visibility, the Environmental Protection Agency (EPA) has promulgated proposed regulations for Visibility Protection for Federal Mandatory Class I Areas (45FR101, pp 34762-34779, 22 May 1980). These regulations would require Utah to address visibility protection in its State Implementation Plan. In any event, visibility is a factor in an environmental impact assessment.

2.4.3.1 Gaseous Pollutants

Air quality was measured at several locations during the baseline monitoring period of the program, and then at fewer sites for the last three years. These data sets are compared in the yearly data reports. A brief description of the general air quality during the entire five years is discussed here.

Sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) were measured at eight sites during the first year of monitoring, four during the second, and one for the remaining time. Ozone (O_3), hydrocarbons (HC), and carbon monoxide (CO) were measured at three of these sites during 1975 and then at one site for the other four years. Because concentrations for most of these pollutants were generally very low and were, in general, fairly uniform over the tracts, these deletions do not affect the representativeness of the data base.

The only pollutant that exceeded any of the NAAQS was nonmethane hydrocarbons (NMHC). However, this standard was developed as a guideline for controlling ozone pollution in urban areas, and not as a health standard. High NMHC values are frequently observed in remote areas, and the high levels on the tracts are not uncommon. These observations could be due to precision problems with the instrument used to measure hydrocarbons, since errors of up to 80 percent of the standard are possible. The precision of the instrument is only $70 \mu\text{g}/\text{m}^3$, and this error can be doubled when obtaining NMHC by subtracting methane (CH_4) from the total hydrocarbon. These problems occur in spite of the fact that the instrument and calibration methods

meet EPA recommendations. Since comparison of measurements with the standard would be meaningless because of this precision problem, exceedance statistics and peak values for them were not analyzed. This decision was made with the approval of the Area Oil Shale Supervisor and the EPA.

The only other gaseous pollutant found in significant amounts was ozone. The highest amount of O_3 measured on the tracts was a one-hour value of $190 \mu\text{g}/\text{m}^3$ at Site A2 in the spring of 1975. (This monitoring station operated only during 1975 and 1976.) The peaks and averages for Site A6 (the one site with a complete five-year data set) is given in Table 2.4-5.

Table 2.4-5
ONE-HOUR OZONE READINGS AT SITE A6 FROM 1975 TO 1979^(a)
($\mu\text{g}/\text{m}^3$)

Season	Highest Concentrations	Second Highest Concentration	Average (1975-1979)	Number of Observations
Winter	150	150	67	9,161
Spring	160	160	75	10,274
Summer	160	160	75	10,400
Fall	150	140	57	9,872

(a) Ozone standard is $235 \mu\text{g}/\text{m}^3$.

The monthly average ozone trend during the five years is shown in Figure 2.4-12. The highest monthly average of $97 \mu\text{g}/\text{m}^3$ occurred in February 1979. In general, highest ozone values occur during the summer, when intense sunlight is available to drive the photochemical reaction. However, occasional high concentrations occur during winter and spring months. A significant cause of these concentrations could be intrusion of stratospheric ozone during frontal passages, according to Reference 2-16.

The diurnal variation of ozone during January and July is shown in Figure 2.4-13. Interestingly, these curves closely follow the diurnal temperature patterns (Figure 2.4-3) and the inverse of the relative humidity (Figure 2.4-5). This emphasizes the close relationship between sunlight and ozone formation, and the seasonal differences in sunlight intensity.

All other gaseous pollutant concentrations were very low, often near the detection threshold of the instrument, and all well below any applicable standards. To permit comparison with standards, the peak pollutant readings for the various time averages are given in Table 2.4-6. Although some of the peaks were measured at sites that operated only during the first two years, the peak concentrations measured at Site A6 (which was operated in all five years) were either nearly the same or much lower during the last three years than concentrations at that location during the first two. Also, activity on the tracts was much greater during the first two years, so most of the peak concentrations occurred during this period. Therefore, these concentrations probably represent the peaks for all sites during the five years. Annual averages at Site A6 for each of the five years for each pollutant are given in Table 2.4-7.

2.4.3.2 Particulates and Trace Elements

Particulates were measured for 24 hours every sixth day at eight sites during the first year of monitoring, at four during the second, and at one in the last three. Also, size-fractionated particulate samples were collected every month during the first two years at Site A2 and analyzed for trace elements. The trace constituents can be a valuable indication of the source of the particulates measured, since soil particles and combustion particles have different chemical makeup.

Table 2.4-8 shows the geometric mean and maximum particulate concentration measured at Site A6. The highest 24-hour average particulate concentration observed on the tracts was $127.4 \mu\text{g}/\text{m}^3$ at Site A5 in the fall of 1975. The highest annual geometric mean was $24.5 \mu\text{g}/\text{m}^3$ at Site A6, also for 1975.

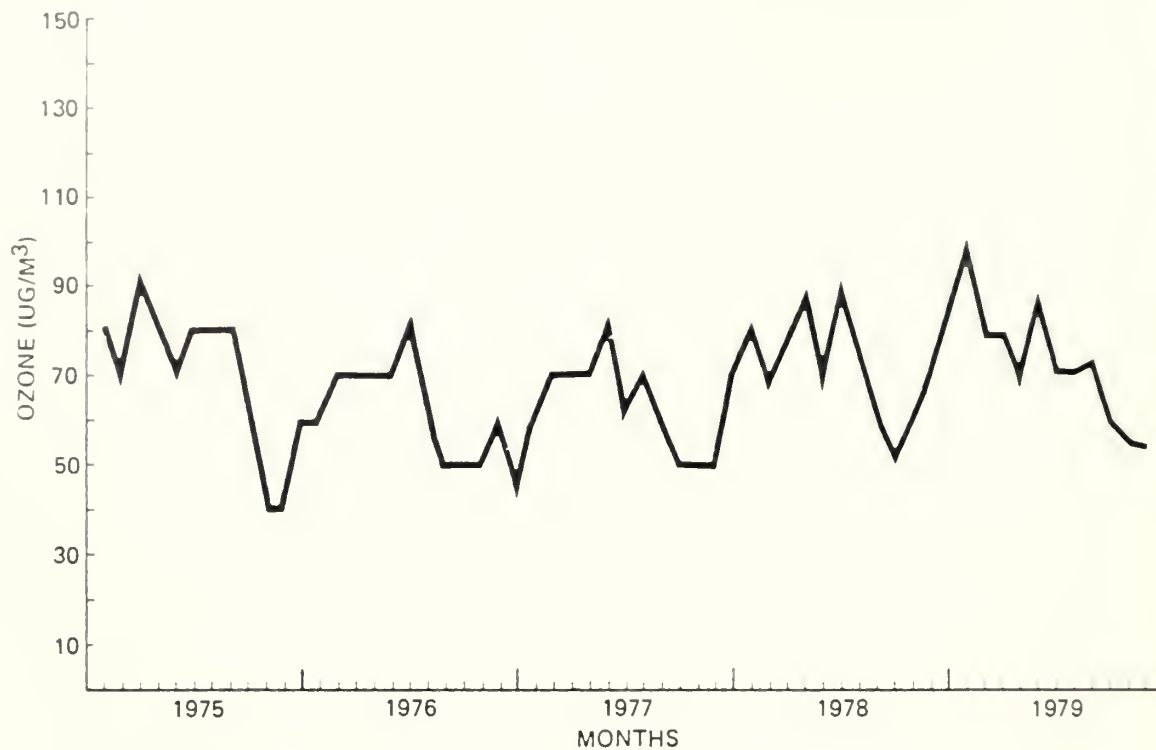


Figure 2.4-12 MONTHLY AVERAGE OZONE AT SITE A6 FROM FEBRUARY 1975 TO DECEMBER 1979



Figure 2.4-13 DIURNAL VARIATION OF MEAN OZONE CONCENTRATIONS AT SITE A6 IN JANUARY AND JULY FROM 1975 TO 1979

Table 2.4-6

PEAK POLLUTANT CONCENTRATION VALUES MEASURED FROM 1975 TO 1979

Pollutant	Site	Averaging Time	Concentration ($\mu\text{g}/\text{m}^3$)	
			Peak	Standard
SO_2	A6	3-hour	94	1,300
	A7	24-hour	25	365
H_2S	A2	1-hour	70	—
CO	A3	1-hour	5.2 (mg/m^3)	40 (mg/m^3)
	A3	8-hour	3.9 (mg/m^3)	10 (mg/m^3)
NO_2	A2	1-hour	190	—

Table 2.4-7

ANNUAL AVERAGES FOR THE GASEOUS POLLUTANTS AND ANNUAL
GEOMETRIC MEAN FOR TSP FROM 1975 TO 1979
($\mu\text{g}/\text{m}^3$)

Pollutant	Annual Averages					Standard
	1975	1976	1977	1978	1979	
O_3	75	63	61	58	74	—
CO (mg/m^3)	0.3	0.2	0.2	0.1	0.1	—
NO_2	6	5	0	1	2	100
SO_2	3	0	0	3	1	80
H_2S	10	3	0	1	0	—
Total Suspended Particulates	24.5	23.5	22.2	15.0	12.5	60

These peaks are most likely due to the more frequent human activity (drilling, driving, monitoring, etc.) in the area during the initial years. The average of the annual geometric means over the five years was $19.5 \mu\text{g}/\text{m}^3$. None of these values exceeded even the secondary standards for annual ($60 \mu\text{g}/\text{m}^3$) or daily ($150 \mu\text{g}/\text{m}^3$) averaging times.

Table 2.4-8

GEOMETRIC MEANS AND MAXIMUM DAILY AVERAGES FOR
PARTICULATES AT SITE A6 FROM 1975 TO 1979
($\mu\text{g}/\text{m}^3$)

Season	1975	1976	1977	1978	1979
Geometric Means					
Winter	—	14.2	13.2	7.2	9.2
Spring	17.2	17.2	22.2	14.2	8.1
Summer	39.2	34.8	27.6	27.2	19.0
Fall	17.2	37.1	22.9	21.3	16.4
Annual	24.5	23.5	22.2	15.0	12.5
Maximum 24-Hour Averages					
Winter	—	51.9	32.6	13.0	19.6
Spring	52.0	45.1	58.3	47.7	34.3
Summer	74.7	63.9	47.2	45.2	35.8
Fall	52.8	101.2	51.4	62.7	52.9

In general, particulate concentrations were lower in the winter because of snow cover and moisture, and higher in the summer and fall. The main sources were most likely wind erosion and fugitive dust from dirt roads. The particulate trend over this period shows a decrease, with the annual mean in 1979 being almost one-half of the 1975 value. This is most likely due to decreased activity on the tracts and increased winter storminess during the last two years.

Trace element analysis showed that, except for the normal soil constituents, most elements were at very low concentrations (10 ng/m^2). Concentrations of the typical anthropogenic aerosol constituents usually found in cities were very low, showing that the source of the particulate is generally natural.

2.4.3.3 Visibility

Visibility was measured on the tracts at Site A9 using photographs, and the scattering of light by airborne particles was measured at Site A2.

Diurnally, the lowest visibilities (highest scattering) were generally observed during the stable night and early morning hours. During the afternoons, when wind and human activities would tend to increase the dust emissions into the air, better ventilation and mixing tended to counteract any visibility degradation.

Seasonally, the best visibilities were observed during the fall. The lowest scattering (best visibility) observed in 1975 to 1976 was $b_s = 0.02 \times 10^{-3} \text{ m}^{-1}$,* which roughly corresponds to a local visual range of 150 miles (235 km). The minimum visual range of 18 miles (29 km) was measured in the spring ($b_s = 0.10 \times 10^{-3} \text{ m}^{-1}$). The average visual range in 1975 was lower than in 1976, with averages of 64 miles and 81 miles, respectively. Since very small increases in atmospheric fine particulate matter concentrations have a strong impact on the visibility in clean areas, this large difference is most probably a consequence of human activity near Site A2 during the first year of the baseline program. Seasonal visual ranges are given in Table 2.4-9. In general, these readings correspond to very good visibility, with a lack of human-caused haze in the area.

* Measured at a wavelength of light of approximately 500 nanometers.

Table 2.4-9

LOCAL VISUAL RANGE VALUES ON SITE A2
FROM 1975 TO 1976(a)
(miles)

Season	Visual Range Value			No. of Observations
	Maximum	Minimum	Average	
Winter	150	29	70	3,778
Spring	150	18	78	3,805
Summer	150	27	65	3,807
Fall	150	31	89	4,345

(a) Determined from integrating nephelometer measurements.

2.4.4 RADIATION

Various radioactivity measurements were taken throughout the tracts during the first two years of monitoring. These included ambient measurements to determine radiation levels in the air, and analysis of particulate filters to measure amounts of airborne radioactive material. During the last three years, only measurements made with thermoluminescent dosimeters were taken.

Radiation levels in the air were fairly consistent at all sites and during all seasons. The average monthly gamma radiation dosage on the tracts was around 12 mR, which is in the normal ambient range. The averages of these dosages for the monitoring period are given in Table 2.4-10. Two air samples analyzed for Radon-222 showed a normal background level of 0.64 pCi/l.

Table 2.4-10

AVERAGE NUCLEAR RADIATION DOSAGE AT TRACTS U_a AND U_b
DURING JUNE 1975 THROUGH MARCH 1979^(a)
(mR)

Site	1975	1976	1977	1978	1979	Average
A4	10.5	12.1	13.1	12.2	10.1	12.0
A6	9.4	11.4	11.6	10.7	9.4	10.8
A11	10.7	13.3	14.5	13.0	11.6	13.0
A13	—	—	11.4	10.0	10.1	10.5

(a) Measured by thermoluminescent dosimeters (TLD).

2.4.5 SOUND LEVELS

Sound level surveys of the study area during April and August 1975 were performed. The surveys showed that the background sound level in wind-free conditions at various locations was 25 to 26 dBA, with air motion or insects as the dominant identifiable sound source. Air stations near the White River indicated a sound level of 30 dBA with no wind; flowing water was identified as the primary sound source. Increases in wind obviously caused higher sound levels, with 60 dBA recorded at Site A4 in an 11 mph wind. Insects were readily identifiable as the dominant source of sound in August, but not in the colder weather of April.

2.5 BIOLOGICAL RESOURCES

The kinds of plants and animals on the tracts reflect their adaptation to the harsh environment of the area. The development of the present desert shrub community has been influenced primarily by climate, including the amount and timing of precipitation, soil types, occurrence of permanent water sources (White River, Evacuation Creek), and invertebrate and vertebrate use of the area. This section has two objectives: to describe the general structure and elements of the tracts' ecosystem, and to summarize some of the important functional relationships that exist between ecosystem components.

2.5.1 TERRESTRIAL VEGETATION

2.5.1.1 Community Types and Distribution

The plant communities on the tracts are part of a widespread and diverse vegetative cover extending over the Uinta Basin. Published reports of the region, aerial photographs, and extensive reconnaissance indicate that the vegetation on the tracts can be grouped into four major vegetation types:

- Sagebrush-greasewood (Type 1)
- Juniper (Type 2)
- Shadscale (Type 3)
- Riparian (Type 4)

Plant species and percentage composition of each vegetation type are reported in Table 2.5-1. The relative abundance of each species is indicated by the percentage of the total plant coverage determined during the baseline sampling programs in 1974-1975. These estimates are representative of present plant species abundance, with the exception of annuals and grasses which vary from year to year with weather and the degree of disturbance by livestock and wildlife. Cover was estimated within 25 percent of the annual or seasonal mean for most species, at the 90 percent level of significance.

Table 2.5-1

PLANT SPECIES IN EACH OF THE PLANT COMMUNITIES

SAGEBRUSH-GREASEWOOD – VEGETATION TYPE 1

Species ^(a)	Common Name	Composition by Percent of Total Plant Coverage ^(d)
Fall 1974 ^(c)		
<i>Sarcobatus vermiculatus</i>	Greasewood	22
<i>Salsola kali</i>	Russian Thistle	21
<i>Artemisia tridentata</i>	Big Sagebrush	17
<i>Artemisia nova</i>	Black Sagebrush	9
<i>Grayia spinosa</i>	Spiny Hop Sage	9
Cryptogams	Lichens	6
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	5
<i>Oryzopsis hymenoides</i>	Indian Ricegrass	4
<i>Atriplex confertifolia</i>	Shadscale	2
<i>Xanthocephalum sarothrae</i>	Snakeweed	2
<i>Tetradymia spinosa</i>	Horsebrush	1
Others ^(b)		2
Spring 1975 ^(c)		
<i>Bromus tectorum</i>	Cheatgrass	17
Boraginaceae	Borage Family	12
<i>Grayia spinosa</i>	Spiny Hop Sage	9
<i>Chrysothamnus nauseosus</i>	Rubber Rabbitbrush	9
<i>Stipa comata</i>	Needle-and-Thread Grass	7
<i>Tetradymia spinosa</i>	Horsebrush	6
<i>Sarcobatus vermiculatus</i>	Greasewood	6
<i>Artemisia tridentata</i>	Big Sagebrush	5
<i>Oryzopsis hymenoides</i>	Indian Ricegrass	3
<i>Mentzelia albicaulis</i>	Small-flowered Mentzelia	3
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	3
<i>Opuntia</i> spp.	Prickly-pear Cactus	2
<i>Artemisia nova</i>	Black Sagebrush	2
<i>Atriplex confertifolia</i>	Shadscale	2
<i>Sitanion hystrix</i>	Squirreltail Grass	2
<i>Eurotia lanata</i>	Winterfat	2
<i>Cleome lutea</i>	Pursh	1
<i>Hilaria jamesii</i>	Galleta Grass	1
<i>Lithospermum ruderae</i>	Puccoon	1
<i>Sphaeralcea coccinea</i>	Copper Mallow	1
<i>Salsola kali</i>	Russian Thistle	1
<i>Artemisia spinescens</i>	Bud Sagebrush	1
Others ^(b)		4

Table 2.5-1 (Continued)

JUNIPER – VEGETATION TYPE 2

Species ^(a)	Common Name	Composition by Percent of Total Plant Coverage ^(d)
Fall 1974 ^(c)		
<i>Juniperus osteosperma</i>	Juniper	81
<i>Artemisia nova</i>	Black Sagebrush	8
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	2
<i>Hilaria jamesii</i>	Galleta Grass	2
<i>Xanthocephalum sarothrae</i>	Snakeweed	1
<i>Atriplex confertifolia</i>	Shadscale	1
<i>Oryzopsis hymenoides</i>	Indian Ricegrass	1
Others ^(b)		4
Spring 1975 ^(c)		
<i>Juniperus osteosperma</i>	Utah Juniper	56
<i>Sarcobatus vermiculatus</i>	Greasewood	7
<i>Chrysothamnus nauseosus</i>	Rubber Rabbitbrush	5
<i>Stipa comata</i>	Needle-and-Thread Grass	4
<i>Hilaria jamesii</i>	Galleta Grass	4
<i>Artemisia tridentata</i>	Big Sagebrush	3
<i>Hedysarum boreale</i>	Sweetvech	3
<i>Hymenoxys scaposa</i>	Hymenoxys	2
<i>Chrysothamnus greenii</i>	Rabbitbrush	2
<i>Artemisia nova</i>	Black Sagebrush	2
<i>Ephedra viridis</i>	Mormon Tea	2
<i>Oryzopsis hymenoides</i>	Indian Ricegrass	2
<i>Phacelia</i> spp.	Phacelia	1
Boraginaceae	Borage Family	1
<i>Atriplex confertifolia</i>	Shadscale	1
<i>Leptodactylon watsonii</i>	Leptodactylon	1
<i>Chenopodium album</i>	Goosefoot	1
Others ^(b)		3

Table 2.5-1 (Continued)

SHADSCALE – VEGETATION TYPE 3

Species ^(a)	Common Name	Composition by Percent of Total Plant Coverage ^(d)
Fall 1974 ^(c)		
<i>Artemisia tridentata</i>	Big Sagebrush	33
<i>Atriplex confertifolia</i>	Shadscale	32
<i>Artemisia nova</i>	Black Sagebrush	12
<i>Hilaria jamesii</i>	Galleta Grass	4
<i>Sarcobatus vermiculatus</i>	Greasewood	4
<i>Tetradymia spinosa</i>	Horsebrush	3
<i>Salsola kali</i>	Russian Thistle	2
<i>Xanthocephalum sarothrae</i>	Snakeweed	2
Cryptogams	Rock Brakes	2
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	1
Others ^(b)		5
Spring 1975 ^(c)		
<i>Bromus tectorum</i>	Cheatgrass	21
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	11
<i>Chrysothamnus greeni</i>	Rabbitbrush	9
<i>Artemisia tridentata</i>	Big Sagebrush	8
<i>Chorispora tenella</i>	Blue Mustard	7
<i>Hilaria jamesii</i>	Galleta Grass	6
<i>Tetradymia spinosa</i>	Horsebrush	6
<i>Sarcobatus vermiculatus</i>	Greasewood	5
<i>Atriplex confertifolia</i>	Shadscale	4
<i>Opuntia</i> spp.	Prickly-pear Cactus	2
<i>Eriogonum effusum</i>	Wild Buckwheat	2
<i>Sporobolus airoides</i>	Alkali Sacaton	2
<i>Stipa comata</i>	Needle-and-Thread Grass	2
<i>Artemisia spinescens</i>	Bud Sagebrush	2
<i>Suaeda torreyana</i>	Sea-blite	2
<i>Sitanion hystrix</i>	Squirreltail Grass	1
<i>Xanthocephalum sarothrae</i>	Snakeweed	1
<i>Suaeda</i> spp.	Sea-blite	1
<i>Oenothera caespitosa</i>	White Stemless Evening Primrose	1
<i>Eurotia lanata</i>	Winterfat	1
<i>Halogeton glomeratus</i>	Halogeton	1
<i>Oryzopsis hymenoides</i>	Indian Ricegrass	1
<i>Eriogonum</i> spp.	Wild Buckwheat	1
Cruciferae	Mustard family	1
<i>Sphaeralcea coccinea</i>	Scarlet Mallow	1
Others ^(b)		1

Table 2.5-1 (Continued)

RIPARIAN – VEGETATION TYPE 4

Species ^(a)	Common Name	Composition by Percent of Total Plant Coverage ^(d)
Fall 1974 ^(c)		
<i>Populus fremontii</i>	Cottonwood	46
<i>Tamarix pentandra</i>	Salt Cedar	17
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	12
<i>Distichlis stricta</i>	Saltgrass	6
<i>Sarcobatus vermiculatus</i>	Greasewood	5
<i>Chrysothamnus nauseosus</i>	Big Rabbitbrush	4
<i>Xanthocephalum sarothrae</i>	Snakeweed	2
<i>Artemisia tridentata</i>	Big Sagebrush	2
<i>Salix exigua</i>	Willow	1
<i>Salsola kali</i>	Russian Thistle	1
<i>Agropyron smithii</i>	Western Wheatgrass	1
Others ^(b)		3
Spring 1975 ^(c)		
<i>Populus fremontii</i>	Cottonwood	28
<i>Bromus tectorum</i>	Cheatgrass	15
<i>Sarcobatus vermiculatus</i>	Greasewood	12
<i>Salix</i> spp.	Willow	9
<i>Tamarix pentandra</i>	Salt Cedar	5
<i>Chrysothamnus viscidiflorus</i>	Sticky Flower Rabbitbrush	4
<i>Chrysothamnus nauseosus</i>	Rubber Rabbitbrush	3
<i>Kochia</i> spp.	Burning-bush	3
<i>Melilotis officinalis</i>	Sweet-clover	2
<i>Poa pratensis</i>	Kentucky Bluegrass	2
<i>Distichlis spicata</i>	Saltgrass	2
<i>Chrysothamnus greenii</i>	Rabbitbrush	2
<i>Lepidium</i> spp.	Peppergrass; Pepperweed	1
<i>Distichlis stricta</i>	Saltgrass	1
<i>Cleome lutea</i>	Pursh	1
<i>Sporobolus airoides</i>	Alkali Sacaton	1
<i>Atriplex canescens</i>	Fourwing Saltbrush	1
<i>Ambrosia psilostachya</i>	Western Ragweed	1
<i>Agropyron smithii</i>	Western Wheatgrass	1
<i>Iva axillaris</i>	Marsh Elder	1
Others ^(b)		5

(a) Taxonomy after Harrington (Ref. 2-17) and Holmgren and Reveal (Ref. 2-18).

(b) This group includes the annuals and grasses. The abundance is subject to change from year to year depending upon the favorability of weather and degree of disturbance by animals (wildlife and livestock).

(c) Extensive botanical sampling performed only during baseline surveys (1974-1975); subsequent studies (1976-present) emphasized specific parameters such as production of biomass of dominant species.

(d) Total plant coverage (100 percent) may vary in area from season to season or year to year. Comparisons of composition, in percent, should only be made between similar seasons (e.g., Fall 1974 with Fall 1975).

The exceptions were those species that occurred infrequently, or whose cover attribute was variable and difficult to estimate. The distribution and topographic location of these four types is shown in Figure 2.5-1.

Sagebrush-Greasewood Vegetation Type. This vegetation type, shown in Figure 2.5-2, is found on deeper soils above the riparian type and below the juniper type. It is extensive and is found on both the broad valleys and canyon bottoms of about 25 percent of the tracts.

The dominant shrubs in the sagebrush-greasewood community are big sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), and shadscale (*Atriplex confertifolia*). Other major shrubs associated with the community include horsebrush (*Tetradymia* spp.), spiny hop sage (*Grayia spinosa*), black sagebrush (*Artemisia nova*), and rabbitbrush (*Chrysothamnus greenii* and *C. viscidiflorus*). The major perennial grasses are Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread grass (*Stipa comata*), and galleta grass (*Hilaria jamesii*). Three introduced annual weed species, cheatgrass (*Bromus tectorum*), Russian thistle (*Salsoia kali*), and halogeton (*Halogeton glomeratus*), are widespread throughout the sagebrush-greasewood vegetation type, often in disturbed areas, and are quite abundant in moist years.

Juniper Vegetation Type. This vegetation type, shown in Figure 2.5-3, is found at higher elevations, usually above 5,400 feet. This type consists of open, sparse stands of juniper mixed with a few pinyon pines (*Pinus edulis*) above 6,000 feet and big sagebrush in draws and valleys. The juniper type covers 35 to 40 percent of the tracts, but is found predominantly on the southern half of Tract Ua.

The juniper community is dominated by Utah Juniper (*Juniperus osteosperma*). Black sagebrush, shadscale, broom snakeweed (*Xanthocephalum sarothrae*), and big sagebrush are the major shrub species. Galleta grass and Indian ricegrass are the most abundant perennial grasses. Vegetation under the canopy of juniper is very limited and consists primarily of peppergrass (*Lepidium montanum*) and other species in the mustard family, needle-and-thread grass,

Kentucky bluegrass (*Poa pratensis*), cheatgrass, phlox (*Phlox lewisii*), and lambs quarter (*Chenopodium album*).

Shadscale Vegetation Type. This vegetation type, shown in Figure 2.5-4, is found on shallow soils of south- and west-facing slopes and along ridgetops where soil depth is less than 18 inches. The most extensive portion is found on Tract Ub on either side of Evacuation Creek. Approximately 29 percent (about 3,000 acres) of the tracts are covered by the shadscale type.

The dominant shrubs of the shadscale community are shadscale and big sagebrush. The other major shrubs include black sagebrush, greasewood, and to a lesser extent hop sage, horsebrush, and rabbitbrush. Herbaceous species include halogeton, milk vetch (*Astragalus* spp.), and Russian thistle. As in the sagebrush-greasewood community, rabbitbrush, halogeton, and Russian thistle are indicative of heavy grazing pressure and disturbance. Indian ricegrass is the dominant fall grass, with needle-and-thread grass and galleta grass represented to a lesser extent.

Cheatgrass dominates the spring growth, with blue mustard (*Thorispora tenella*) and other species in the mustard family the dominant herbs.

Riparian Vegetation Type. This vegetation type, shown in Figure 2.5-5, is found along stream courses and river bottoms. Only two ontract areas are classified as riparian: the borders of Evacuation Creek and the floodplain of the White River. The soils of the narrow Evacuation Creek bottom lands are considerably more saline than those of the White River. The riparian type constitutes approximately 2 percent (about 240 acres) of the vegetation on the project area.

Cottonwood (*Populus fremontii*) dominates the riparian community along the White River, with salt cedar (*Tamarix pentandra*) the dominant understory shrub. In the riparian area along Evacuation Creek, salt cedar and greasewood are the dominant shrubs. Horsetail (*Equisetum arvense*), rabbitbrush

LEGEND

- 1 - SAGEBRUSH-GREASEWOOD
- 2 - JUNIPER
- 3 - SHADSCALE
- 4 - RIPARIAN



PHOTO MOSAIC; NOT TO SCALE

Figure 2.5-1 VEGETATION MAP



Figure 2.5-2 SAGEBRUSH-GREASEWOOD TYPE OF SOUTHAM CANYON
(WITH JUNIPER IN BACKGROUND)

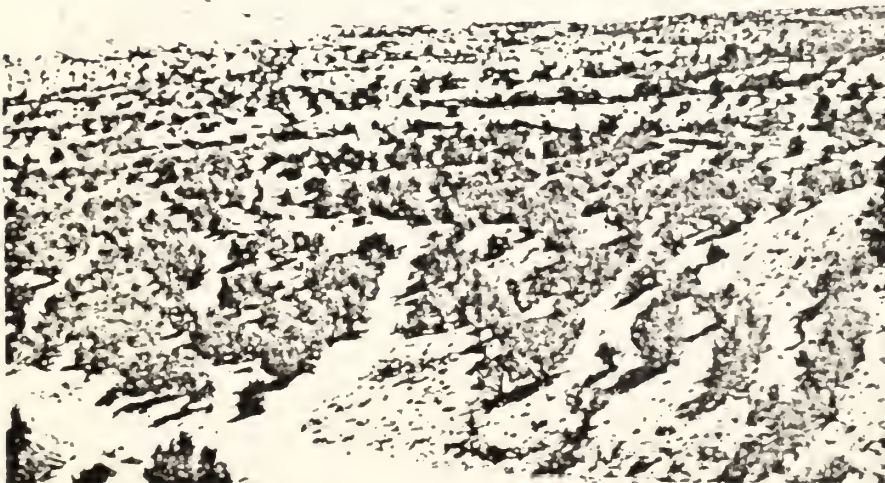


Figure 2.5-3 JUNIPER VEGETATION TYPE AT HIGHER ELEVATIONS



Figure 2.5-4 SHADSCALE VEGETATION ON HILLS
(SAGEBRUSH-GREASEWOOD IN FOREGROUND)



Figure 2.5-5 RIPARIAN VEGETATION TYPE ALONG THE WHITE RIVER

(*Artemisia tridentata* and *A. tridentata*), and wire rush (*Eleocharis acicularis*) are also dominant understory plants. Other major shrubs include greasewood and willow (*Salix exigua*). Russian thistle, yellow sweet clover, annual atriplex (*A. patula*), and snakeweed are the major herbaceous species. Saltgrass (*Distichlis stricta*) is the dominant grass with western wheatgrass (*Agropyron smithii*), muhly (*Muhlenbergia asperifolia*), and Kentucky bluegrass expressing lesser dominance. Spring growth is dominated by cheatgrass, peppergrass (*Lepidium perfoliatum*), and other species of the mustard family. Other herbs and grasses occurring in the riparian community include kochia (*Kochia* spp.), stickseed, and species of the borage family, blue mustard, smother weed (*Bassia hyssopifolia*), sixweeks fescue (*Festuca octoflora*), sand bur (*Cenchrus pauciflorus*), ragweed (*Ambrosia psilostachya*), and poverty weed (*Iva axillaris*).

Most of the annual species mature in the spring when soil moisture is favorable. Perennial grasses mature in early summer, while shrubs grow and produce seeds over an extended period of time, ranging from June for spiny horsebrush to October for shadscale.

When considered from a regional viewpoint, the sagebrush, greasewood, and shadscale vegetarian types on site are a part of plant associations extending to the north and west for 30 to 60 miles. Similarly, the juniper vegetation type found on Tracts Ua and Ub (about 4,500 acres) continue into the southern and eastern portions of the Uinta Basin for 20 to 30 miles. Ecologically equivalent plant communities may be found in parts of the Colorado Plateau and the Great Basin.

2.5.1.2 Productivity

Productivity studies of spring-maturing annual species (Table 2.5-2) indicate that the riparian vegetation type is by far the most productive on the tracts. However, productivity measurements in 1975 to 1979 show the wide fluctuation in average yearly biomass production of each community. The year 1975 was one in which precipitation, though average in overall quantity, fell at evenly spaced intervals during the early growing season and resulted in unusually prolific plant growth. In contrast, meager biomass production in other years reflects poor spring weather conditions. Therefore, productivity of annual species must be considered a highly variable vegetation characteristic with important implications for various ecosystem processes, particularly in animal population dynamics.

Perennial species production is not as closely related to spring rainfall as that of annual species because plants are already in place and do not have to start from seeds each year. Estimates of production by perennial forbs, shrubs, and trees in the fall of 1974 and 1975 (Table 2.5-3) show considerably less fluctuation in production between years than for annuals.

We may conclude that productivity fluctuates annually and differs according to the vegetation type. Growth of annuals occurs primarily in early spring, but perennial plant species will continue growing as long as water is available (sometimes until late August). Therefore, productivity also varies seasonally and the greatest amount of forage and cover for animal species using habitats on the tracts will be available primarily in the late spring and early summer. Perennial woody plants produce consistent amounts of biomass each year and in addition retain the growth of previous years to give stability to the vegetation type.

Table 2.5-2

AVERAGE SPRING SEASON BIOMASS PRODUCTION OF ANNUAL
SPECIES ON TRACTS Ua AND Ub^(a)
(g/m²)

Year	Vegetation Type			
	Shadscale	Sagebrush-greasewood	Juniper	Riparian
1975 ^(b)	224.3	51.1	3.8	533.3
1976 ^(b)	3.8	20.9	.25	30.6
1977	(c)	(c)	(c)	20.6
1978	5.4	35.1	1.6	80.0
1979	16.4	16.9	6.3	82.5

(a) Each value is the mean of 50 plots.

(b) Data taken from Final Environmental Baseline Report (Ref. 2-1) and from extended monitoring program.

(c) Vegetation not sampled, too meager to harvest.

Table 2.5-3

COMPARISON OF PRODUCTION OF PERENNIAL SHRUBS, TREES,
FORBS, AND LATE-MATURING ANNUALS WITHIN
THE FOUR VEGETATION TYPES^(a,b)
(g/m²)

Vegetation Type	Production ^(c)	
	September 1974	September 1975
Sagebrush-Greasewood	186.8	164.3
Juniper	251.8	133.2
Shadscale	130.3	130.6
Riparian	588.3	303.5

(a) Mean production is calculated on 100-plot basis.

(b) Extensive botanical sampling performed only during baseline survey (1974-1975); subsequent monitoring emphasized parameters such as production at dominant species.

(c) Estimates of production were made on the basis of clippings from 10 cm² samples from the plant canopy.

2.5.1.3 Plant Cover

The amount of plant cover displayed by each vegetation type is a characteristic important in such functions as the control of soil erosion and wildlife habitat management, as well as livestock carrying capacity. Further, the amount of cover measured prior to disturbance can serve as a major criterion and goal in obtaining adequate land rehabilitation. Estimates of cover made during the baseline inventory show a fluctuation between fall and spring (Table 2.5-4). The higher amount of plant cover in the spring is a function of the greater amount of annual vegetation at that time. Differences in cover between years for fall cover estimates are a reflection of favorable growth conditions in the summer and fall for perennial species. Obviously, the amount of cover differs considerably from one vegetation type to another, with shadscale and sagebrush-greasewood having the lowest percentage cover and riparian the highest.

Table 2.5-4

PERCENT OF PLANT COVER OBSERVED ON THE FOUR
VEGETATION TYPES IN FALL AND SPRING^(a)

Vegetation Type	Fall 1974	Spring 1975	Fall 1975	Spring 1976	Mean
Sagebrush/Greasewood	7.03	12.10	11.47	10.36	10.2
Juniper	14.44	16.54	17.30	21.34	17.4
Shadscale	8.28	13.80	12.48	8.25	10.7
Riparian	27.83	37.02	27.34	28.60	30.2
Mean Plant Cover	14.4	19.86	17.1	17.2	

(a) Total area of plant cover varies from year to year and season to season; comparisons of percent plant cover should be made within vegetation types (e.g., shadscale, fall 1974 with shadscale, spring 1975) or between similar seasons (e.g., fall 1974).

2.5.1.4 Threatened or Endangered Plants

No threatened or endangered plants have been found during onsite vegetation surveys.

2.5.2 MICROORGANISMS

Microorganisms are important in the cycling of mineral nutrients in all natural ecosystems. Mineralization (decomposition) of organic material and the consequent release of vital plant nutrients is a major function of microorganisms. Nitrogen fixation and nitrification are also important processes carried out by microbes. Hence, microbial activities play a major role in structuring and controlling process rates of ecosystems.

Microbial and biochemical activities measured on the oil shale tracts resemble the behavior of these activities in similar western arid areas. The annual detritus and litter fall decomposes rapidly, and little organic matter accumulates in the soil except under the juniper canopies. Decomposition of organic material, as well as other microbial activities, is strongly moisture-dependent and is generally limited to spring and fall when the soil is moist and the temperatures are above freezing. In the summer, favorable climatic conditions for microbial activity occur only after rainy periods, which moderate the high soil temperatures and low soil moisture contents characteristic of the season.

The spatial distribution of microorganisms is closely related to the horizontal and vertical distribution of organic materials in the soil. Microbial populations are concentrated under the canopies of shrubs and trees where organic input to the soil via litter fall is highest. Microbial numbers decrease with increasing depth in the soil, corresponding to decreasing amounts of organic material, which is needed as an energy source. In effect, a mutualistic plant-microbe system exists, as an island in a desert, functioning in response to temperature and rainfall.

The four community types recognized on the tracts exhibit different soil, vegetation, and microbial characteristics. Although microbial differences between the upland communities appear primarily related to the organic carbon content of the soil, moisture and salinity may also have some importance. The riparian areas showed the most microbial activity, owing to the high primary production and the availability of water from the White River. In the upland areas, the juniper community had the highest levels of microbial activity, corresponding to high levels of productivity and therefore high levels of organic material in the soil. The shadscale community had the lowest microbial activity as well as the lowest soil organic carbon content. The sagebrush-greasewood community was intermediate in activity and organic carbon content.

2.5.3 TERRESTRIAL INVERTEBRATES

2.5.3.1 Species Inventory

About 1,500 species of insects were collected during the baseline study, but there was no concerted effort to collect non-insect arthropods or other invertebrates. Other arthropods observed in conjunction with the insect collection program include spiders, mites, scorpions, pseudo-scorpions, sun spiders, harvestmen, centipedes, and millipedes. Mites are the most diverse of the noninsect orders. Other terrestrial invertebrates (except for microscopic forms) are few in number and low in diversity.

Hymenoptera (bees, wasps, and ants) account for one-third of all insect species on the tracts; Diptera (flies, gnats, etc.) account for two-sevenths of all species; Coleoptera (beetles) account for about one-sixth; and Hemiptera (bugs, leafhoppers, etc.) account for one-eighth. Other groups constitute the remainder of the total. These estimates are somewhat biased because of the collecting methods used. More collecting and trapping at night could greatly increase the number of nocturnal Lepidoptera (moths) and would probably reveal them to be almost as diverse as Hemiptera.

Terrestrial invertebrates play two important roles in the desert ecosystem. Because microbial decomposition occurs only under limited favorable climatic conditions, detritus breakdown by invertebrates is important in nutrient cycling, especially during the dry periods. Also, invertebrates form an important food base for many vertebrate species.

2.5.3.2 Arthropods of Nuisance or Public Health Significance

Some insects in the area are significant pests to man and domestic animals or are potential public health hazards. Among the Diptera, a mosquito (*Aedes nigromaculis*), a biting midge (*Leptoconops furens*), and a deer fly (*Sylvius quadrivittatus*) are the principal biting species. All are extremely annoying when present in large numbers in the riparian areas, and *L. furens* is also troublesome in the more upland areas. Several other biting Diptera, such as other biting midges (*Culicoides*) and mosquitoes, horseflies or deerflies (*Tabanidae*), and the stable fly (*Stomoxys calcitrans*), probably exist in the area and may become pests.

Ticks were not collected, although they undoubtedly are found on the resident deer.

The black widow spider and a species of scorpion are also present. The scorpion is harmless, and the bite of the black widow, although it is painful and can cause cramps, is usually not fatal.

Filth-carrying flies, such as houseflies and blowflies, although present, are not abundant. The most common is *Phormna regina*, a blowfly that commonly breeds in carcasses of deer and large livestock. As human habitation increases, it is possible that the populations of these pests will increase, unless good sanitation precautions are taken.

2.5.3.3 Protected Arthropod Species

Several species of swallowtail butterflies (*Papilio* sp.) are being considered by the U.S. Fish and Wildlife Service for addition to the national rare and endangered species list. None of these were found on the site, but they may reside in the area, since they are found in the vegetation typical of the region.

2.5.4 TERRESTRIAL VERTEBRATES

There are two major groups of vertebrates in the project area: one consists of true desert fauna adapted to an arid environment, and the other consists of fauna that require access to surface water. Distinct distributional patterns corresponding to habitat type for each group are evident.

Climate affects vertebrate distribution and density on the tracts, both directly and via its effect on the plant communities. Large vertebrates such as deer move from one elevation and exposure to another in winter in response to temperature and food availability; migrant species appear on site only during favorable seasons; still other species burrow; and a few may hibernate during periods of extreme temperatures and when food is scarce. Diurnal behavioral patterns revolve around temperature fluctuations, especially during winter and summer. In general, aboveground vertebrate density and species compositions on the tracts vary with the season. Yearly variation in populations is also high. The species composition for each season for five years of study in the four vegetation types on the tracts is summarized in Table 2.5-5.

2.5.4.1 Game Species

Big Game. Mule deer (*Odocoileus hemionus*) are the only big game species found on the tracts. Pronghorn (*Antilocapra americana*) occur north of the tracts and were encountered once within 1.6 kilometers of the tract's border during the 1977 drought. American elk (*Cervus canadensis*) occur at higher elevations south of the tracts.

Table 2.5-5

SPECIES COMPOSITION OF TERRESTRIAL VERTEBRATES
ON TRACTS Ua AND Ub

Vegetation Type	Vertebrate Class	Mean Number ± Different Species ± Standard Deviation (a)					Mean Number ± Standard Error For All Seasons and Years	Total Number of Different Species by Habitat 1975-1979
		Feb 1975- 1979	Apr 1975- 1979	June 1975- 1979	Aug 1975- 1979	Oct 75-76, 76-79		
Sagebrush- greasewood	Mammals	6±2	10±2	15±3 ^(b)	16±3 ^(b)	8±4	11±2	31
	Birds	10±2	23±2	31±10	23±5	16±4	21±4	78
	Reptiles	—	1±1	6±1	7±2	2±2	3±1	8
	Amphibians	—	0±2 ^(c)	0±4 ^(c)	0	—	0.1±0.1	—
	$\bar{x} \pm SE$	4±2	9±5	13±7	12±5	6±4		
Shadscale	Mammals	4±3	8±2	10±2	10±3	7±3	8±1	27
	Birds	8±4	23±4	25±5	19±3	13±4	18±3	54
	Reptiles	—	2±1	6±1	6±2	2±2	3±1	9
	Amphibians	—	0	0	0	0	0	0
	$\bar{x} \pm SE$	3±2	8±5	10±5	9±4	6±3		
Juniper	Mammals	5±1	9±3	10±2	11±3	8±3	9±1	16
	Birds	11±4	18±3	27±5	20±3	15±3	18±3	69
	Reptiles	—	1±1	6±1	6±1	3±4	3±1	5
	Amphibians	—	0	0	0	—	0	0
	$\bar{x} \pm SE$	4±3	7±4	11±6	9±4	6±3		
Riparian	Mammals	6±2	8±1	10±3	10±4	10±4	9±1	24
	Birds	15±4	42±5	55±13	41±3	26±8	36±7	129
	Reptiles	—	2±1	7±1	6±2	3±2	4±1	6
	Amphibians	—	0	2±2	2±1	—	1±0.5	—
	$\bar{x} \pm SE$	5±4	13±10	18±12	15±9	10±6		
Total Different Species in All Habitats								
Mammals								41
Birds								139
Reptiles								11
Amphibians								—

(a) Sample number = 5 for each season.

(b) Includes bats (*Chiroptera*) captured at Asphalt Wash pond.

(c) Includes amphibians observed at Asphalt Wash pond.

Mule deer are encountered in all habitats on the tracts. Based on movement data from radio transmitter-assisted surveys for two years and ground observations through five years, the riparian vegetation on the White River was established to be a focal point of deer activity from spring through fall. From 150 to 250 deer were sighted in 1975-1977, and following the drought, 75 to 150 deer used the river bottom for cover. The area is crucial for does who spend most of their fawning and nursing periods along the river corridor. Bucks are occasionally found along the river. Their preferred habitat, however, is the White River Breaks north and south of the river. Fawn production based on fawn:doe ratios averaged 76 in 1975-1976 on the tracts compared with a production of 66 to 75 during 1975-1978 for the Book Cliffs Resource Area (Area 28A) of which the tracts are a part (Ref. 2-19).

Habitat preference for foraging is, in order of importance: shadscale, juniper, and sagebrush-greasewood. The deer move up the side canyons of the White River in the evening to browse and return to the river bottom or the sandstone escarpments in the Breaks during the day. Riverine areas are avoided during winter, presumably because cold air drainage makes these areas much colder than the surrounding uplands.

One of the major wintering grounds in the area occurs on site (Figure 2.5-6). It extends from the eastern border of Southam Canyon to Evacuation Creek. Deer range through the juniper woodland on the south-facing canyon sides.

Small Game. The mountain lion (*Felis concolor*), classified as small game in Utah, is a casual visitor in the area, and its population center is the Book and Roan cliffs some 30 to 40 miles south of the tracts (Ref. 2-20). The desert cottontail (*Sylvilagus auduboni*) is the only small game mammal occurring on the tracts. It occurs in all habitats, and its populations are cyclic. Its population peaked in 1976, with lows in 1975 and 1979. Its preferred habitat is sagebrush-greasewood, where it sustained a relatively high population in 1978 when abundance in other habitats was

LEGEND

■ WINTERING AREAS

➔ MIGRATION ROUTES

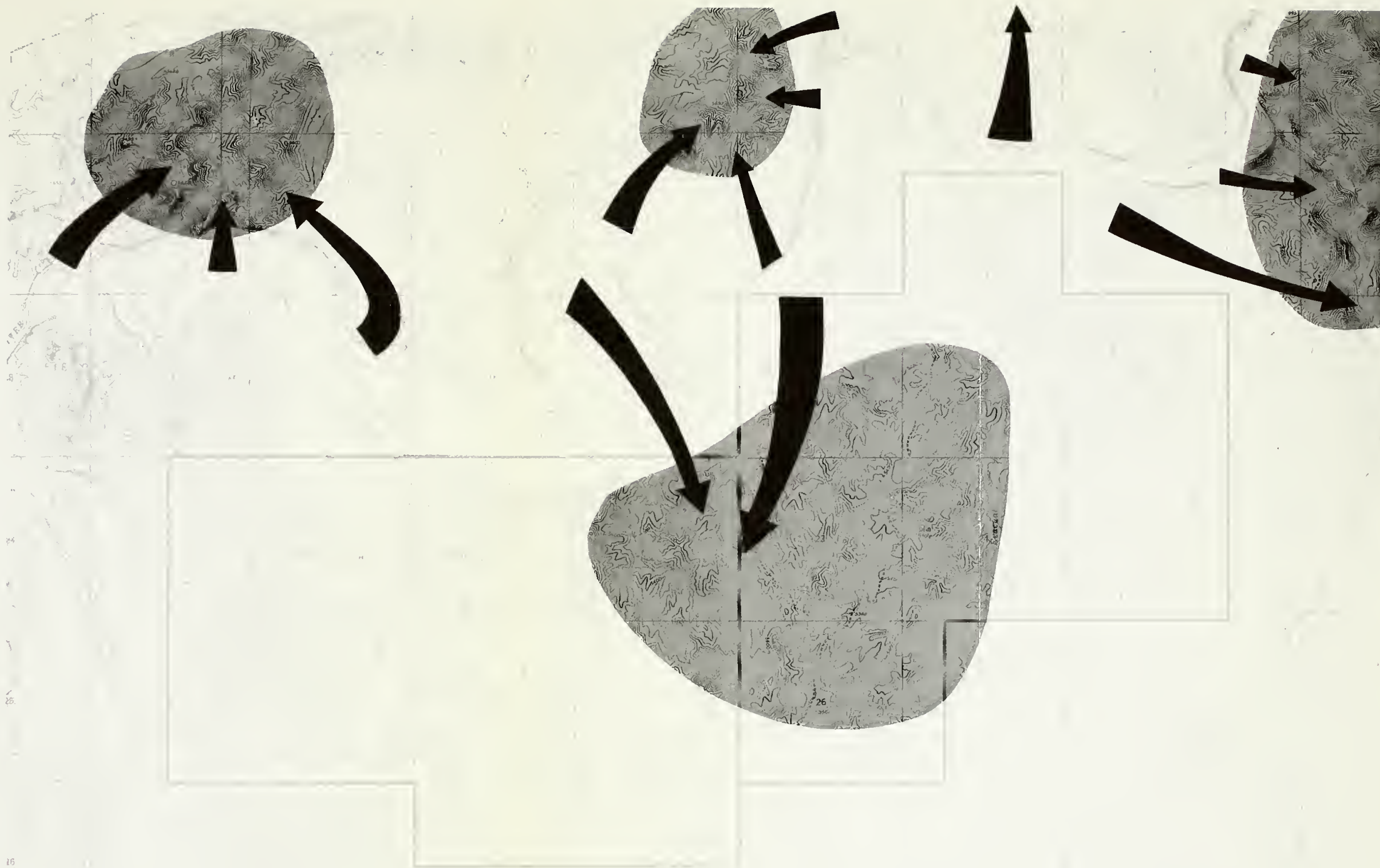


Figure 2.5-6 DEER MIGRATION ROUTES
AND WINTERING AREAS

depressed. However, no significant habitat preference was found from the abundance data.

Game birds that occur in the tracts are waterfowl and mourning doves. Only two species of gallinaceous birds were encountered during five years — two ring-necked pheasants in 1976 and one chukar in 1977. Common snipe occurred only as uncommon-to-rare spring migrants along the White River.

Mourning doves are found in all habitat types from April through August. Preferred habitats are the riparian community along the White River and the sagebrush-greasewood community in Southam Canyon and Asphalt Wash. Abundance peaked in 1975 (3.3 ± 1.0 doves/km)* and has since declined, ranging between a mean of 0.4 to 0.8 dove/km between 1976 and 1979. Ten species of waterfowl use the river corridor. These are seven transient species with uncommon-to-rare abundance and three nesting species — Canada geese, mallard ducks, and green-winged teal. The mallards and teal also nest in small ponds located in Asphalt Wash off tracts Ua and Ub. Of the nesting species, the geese are the most abundant.

The geese arrive in February and reach peak abundance in June. Usually, the geese leave the vicinity of the tracts by late July. However, during the 1977 drought they remained on the river through August. Small flocks also occurred in the river corridor during October 1978 and 1979. Based on the correlation of geese seen on the river by Utah Division of Wildlife Resource personnel during 1975-1976 and flushing transect data collected at the same time (correlation of regression = $\rho^{**} < 0.05$), the average population

* 3.3 ± 1.0 is a mean ($\bar{x}$) of 3.3 plus or minus a standard error at 1. In other words, there is a 95 percent probability that between 2.3 and 4.3 mourning doves occur in each kilometer of flushing transect.

** ρ = level of significance, indicating probability of occurrence.

on tract of geese and goslings in the study area is 44 ± 3 during June from 1975 to 1979. The number of mallards and green-winged teal nesting along the White River is low. Their occurrence as nesters is sporadic. Both species reached peak abundance in the study area during the 1977 drought.

2.5.4.2 Livestock

The tracts and boundary area are used by livestock in accordance with Bureau of Land Management (BLM) allotments (Figure 2.5-7). Four upland areas are used to graze domestic sheep (*Ovis aries*), and the river bottom is used to graze cattle (*Bos taurus*). Animal unit months (AUM)^{*} from 1975-1979 for sheep averaged 3,089 AUMs in the Wagon Hound allotment, 918 AUMs in the Hell's Hole allotment, and 1,103 AUMs in the Asphalt Draw allotment (not shown on the map). The sheep in the Little Emma-Southam Canyon allotment are a split herd, with approximately 1,800 sheep grazed in Southam Canyon and side canyons of Asphalt Wash from December through April. The remainder of the flock graze north of the White River. The flocks using the Wagon Hound and Hells Hole allotments are present in December for a short period, and return to graze in late March through April prior to shearing and transportation to higher elevations for lambing and summer grazing. The Asphalt Draw allotment has little influence on the tracts except that part of the 14,000 to 21,000 sheep that are driven through the tracts twice a year via the stock driveway come from this allotment. Total tract use by sheep from 1975 to 1979 (excluding the sheep in the Little Emma area and Asphalt Draw Allotment) and use during the sheep drives averaged $33,489 \pm 557$ AUMs.

Approximately 160 cattle graze the White River bottom lands from late June to late October. The average use is 457 ± 18 AUMs. The distance from the river grazed by cattle varies from year to year. Usually, they forage within a kilometer of the river, in side canyons and onto some upland areas. However, in the 1977 drought, they traveled 4 to 5 kilometers from the river, some grazing as far north as Bonanza, Utah and others traveling south via Evacuation Creek and Asphalt Wash.

*An animal unit month is the amount of forage on an acre of land required to support one cow or five sheep for one month.

- LEGEND**
- CATTLE GRAZING ALLOTMENT
 - SHEEP GRAZING ALLOTMENT
 - STOCK DRIVEWAY

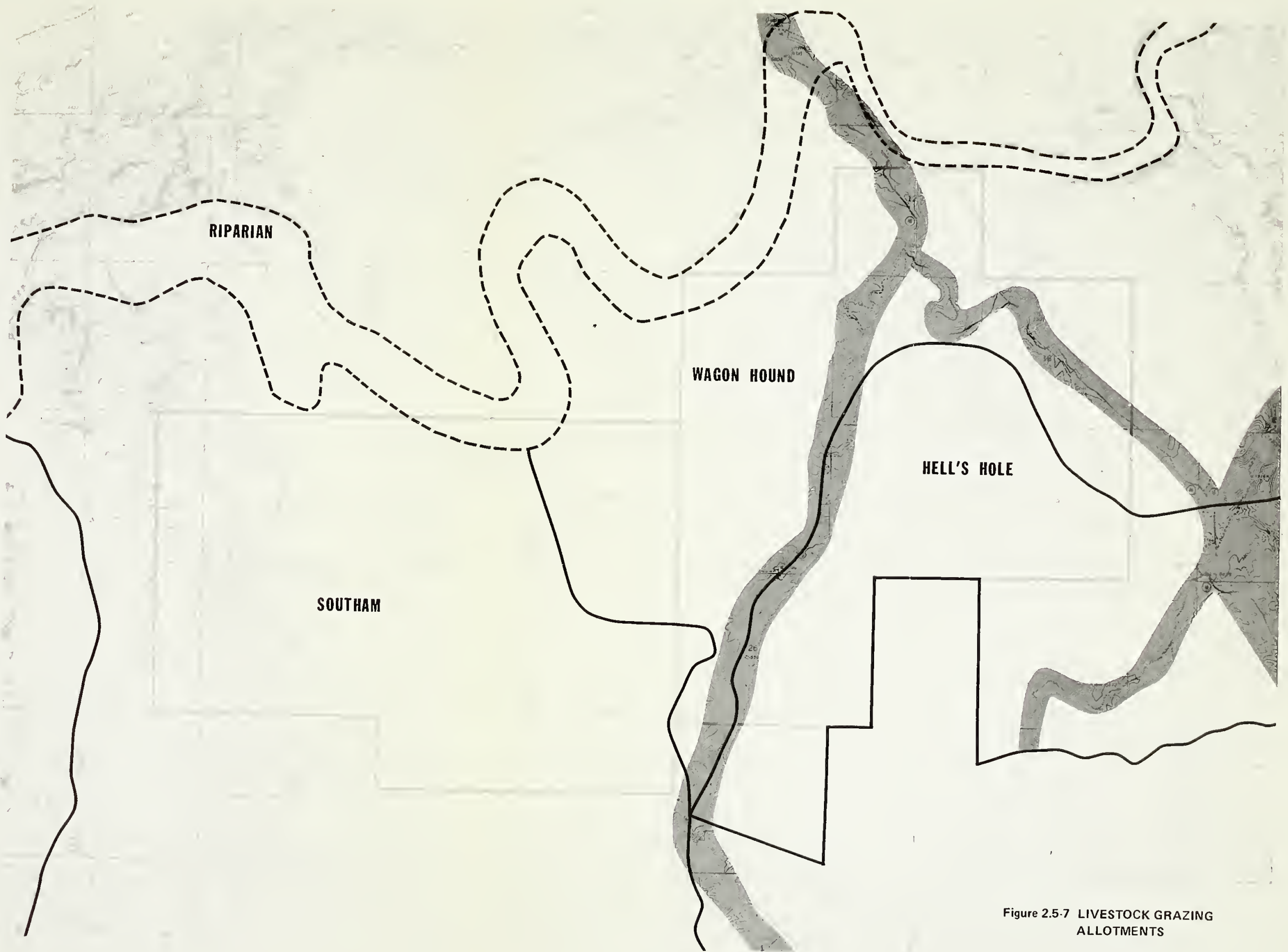


Figure 2.5-7 LIVESTOCK GRAZING ALLOTMENTS

2.5.4.3 Nongame Mammals

Thirty-five nongame species of mammals occurred on the tracts from 1975 to 1979. Three rodent species were found prior to the baseline (Refs. 2-20 and 2-21), but they have not been encountered since. Of the 35 mammals, there were 10 bats, 18 rodents, six carnivores, and 1 lagomorph.

Bats occur in all habitat types. Some of the bats roost in the trees along the White River and forage in the uplands; others roost in crevices and caves found in the sandstone on the tracts. Bat abundance and number of species peaked in 1978. The highest concentration of bats is found at small ponds in Asphalt Wash amid a sagebrush-greasewood community. The most common species were the small western pipistrel (*Pipistrellus hesperus*) and the large hoary bat (*Lasiurus cinereus*).

The lagomorph found on the tracts other than the desert cottontail was the black-tailed jackrabbit (*Lepus californicus*). Its occurrence is sporadic and it is considered rare on the tracts. It is more abundant north of the White River in the sagebrush and juniper habitats.

Rodent densities, determined by live-trap grids in each vegetation community, were high in 1975 (significantly higher than 1977-1979 as determined by Fisher Least Significant Difference Test, $p < 0.01$), erupted in 1976, declined drastically in 1977, and remained low through 1978 and 1979. The number of rodent species also peaked in 1976, with 1977 and 1979 supporting the fewest kinds of rodents ($p < 0.05$).

Densities within vegetation communities through five years averaged 21 ± 6 rodents/ha in sagebrush-greasewood and 18 ± 8 rodents/ha in shadscale (the two shrub communities). In the wooded habitats, the juniper supported 14 ± 5 rodents/ha and the riparian, 13 ± 5 rodents/ha. Sagebrush-greasewood supported significantly higher rodent densities than the wooded communities ($c < 0.05$). The juniper supported a more diverse group of rodents than the riparian and shadscale habitats. The two shrub communities also supported a more diverse group of rodents than the riparian community.

The riparian community supports few species and low densities of rodents. This is due to wet silt and clay soils which are not conducive to burrow construction, especially in winter when the soils freeze. The juniper supports a low density but a high number of species. The low density is probably due to the lack of understory vegetation and shallow soils. However, the diverse vegetation that is present, including the juniper trees, and the variety of physical niches support a diverse rodent community. The shrub communities with their deep, porous, sandy soils and the potential for high annual production may be responsible for high densities and moderate rodent diversity.

Several species of rodents were not accounted for by trapping. The white-tailed prairie dog (*Cynomys leucurus*) had an established town from 1975 to 1977 in the northeast section of the 1.6-kilometer perimeter around the tracts. Since late 1977, this town has been inactive. Numerous beaver (*Castor canadensis*) live in the banks along the river corridor and feed on sapling cottonwood trees. Although this appears destructive, the beaver actually thin young stands of trees, reducing competition and allowing for the growth of large cottonwoods. Muskrat (*Ondatra zibethicus*) occur all along the river although they are uncommon. Porcupine (*Erethizon dorsatum*) are common in the large cottonwoods along the White River and uncommon to rare among the upland juniper.

The small rodent communities appear to differ markedly from other communities in similar habitats in Utah. The rodents on the tracts are eruptive and can maintain higher densities than rodent communities studied intensively in the Curlew Valley of Utah-Idaho by the Desert Biome Program (Ref. 2-22). There are two possible reasons for this: the topography of the tracts is highly dissected compared with that of the Curlew Valley; the desert bloom did not occur during the Biome program as it did on the tracts.

Of the six carnivores on the tracts, the coyote (*Canis latrans*) is the most numerous and is found in all habitats. Its abundance is considered

uncommon. Two mustelids and a felid — the badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), and bobcat (*Lynx rufus*) — are rare. The badger and bobcat are found in all habitats and the skunk is found only in the riparian community. The gray fox (*Urocyon cinereoargenteus*) and the long-tailed weasel (*Mustela frenata*) were sighted only once in five years, the former along the White River, the latter in a sagebrush-greasewood and juniper ecotone.

No threatened and endangered mammals occurred on or within the 1.6-kilometer perimeter of the tracts. Had the prairie dog town been a stable population like those towns in the Coyote Basin on the Utah-Colorado border northeast of the tracts, the occurrence of black-footed ferrets (*Mustela nigripes*) would have been possible. However, the dog town in the perimeter is not large enough nor stable enough to meet the criteria for a ferret's occurrence (Ref. 2-23).

2.5.4.4 Nongame Birds

A total of 114 species of nongame birds inhabited the tracts during different times of the year. Residency status and mean annual abundance of these species are shown in Table 2.5-6. Total avian abundance as determined by the calendar year shows that 1976 was a peak year. However, avian yearly cycles do not correspond to our calendar year; the cycle begins in spring with the initiation of the growing season when migrants move in from the south and the winter residents move back into the mountains. Hence, the number of birds counted in the winter of 1976 were actually part of the 1975 population cycle. If their abundance is attributed to 1975, the magnitude of plant and invertebrate production that took place in 1975 is also reflected in avian abundance, as shown in Table 2.5-6. Abundance of nongame permanent residents remained stable in 1975 and 1978-1979. An increase in 1976 was due to high numbers of horned larks (*Eremophilus alpestris*) that foraged on the tracts in winter. A decline in abundance in 1977 was due to the drought, which affected all the animal species on the tracts. The summer residents peaked in 1975, declined, and

Table 2.5-6

NONGAME BIRD RESIDENCY STATUS, NUMBER OF SPECIES, AND ABUNDANCE ON TRACTS Ua AND Ub

Residency Status	Number of Species	Mean Abundance Number/Kilometer $\pm$ Standard Error				
		1975	1976	1977	1978	1979
Permanent Residents	9	8 $\pm$ 5	10 $\pm$ 4	4 $\pm$ 1	8 $\pm$ 4	8 $\pm$ 6
Summer Residents						
Consistent occurrence	36	6 $\pm$ 2	4 $\pm$ 1	3 $\pm$ 1	4 $\pm$ 1	4 $\pm$ 1
Irregular occurrence	21	< 1 (n=16)	< 1 (n=15)	< 1 (n=12)	< 1 (n=9)	< 1 (n=11)
Transients and migrants						
Consistent occurrence	9	1 $\pm$ 0.4	2 $\pm$ 1	< 1	< 1	< 1
Irregular occurrence	32	< 1 (n=16)	< 1 (n=22)	< 1 (n=8)	< 1 (n=10)	< 1 (n=14)
Winter Residents						
Consistent occurrence	3	5 $\pm$ 5	30 $\pm$ 14	6 $\pm$ 3	4 $\pm$ 2	16 $\pm$ 16
Irregular occurrence	4	< 1 (n=3)	2 $\pm$ 2 (n=3)	0 (n=0)	0 (n=1)	< 1 (n=1)
Total	114	22 (n=92)	49 (n=97)	14 (n=77)	17 (n=77)	29 (n=83)
Total with attributing of winter abundance to previous year		49 (n=92)	23 (n=94)	12 (n=78)	29 (n=78)	—

then maintained a stable abundance. The transients and migrants reached peak abundance in 1976 and have since declined in abundance and in number of species. The few species of winter residents were the most volatile group of nongame birds, reaching their peak in winter of 1976.

Most of the nongame birds were passerines (83 percent), and most of those birds (90 percent) used the riparian habitat at some time during a year. The riparian community supported the most birds ($p < 0.01$) and the most species ($p < 0.01$) on the tracts. There were 17 obligate species (animals that are restricted to or dependent on a specific vegetation community) along the White River. Twelve were nongame birds, four were waterfowl, and one was a raptor. Four birds were obligate residents of the juniper type, six species were obligate residents of shadscale, and one species was an obligate resident of sagebrush-greasewood.

Nongame ubiquitous species are those found in all habitat types. There was one permanent resident (the black-billed magpie, *Pica pica*), four summer residents (the common nighthawk, *Chordeiles minor*; Say's phoebe, *Sayornis saya*; rock wren, *Salpinctes obsoletus*; and the mountain bluebird, *Sialia currucoides*), and two winter residents (the common raven, *Corvus corax*, and the black rosy finch, *Leucosticte astrata*).

Raptors. Seventeen raptor species occurred on or near the tracts — eight species consistently, nine species irregularly. Red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), American kestrels (*Falco sparverius*), and great horned owls (*Bubo virginianus*) commonly nest and breed on the tracts. Red-tailed hawks and great horned owls nest in the trees, rock crevices, and caves along the river corridor. Golden eagles and American kestrels nest in the upland sandstone cliffs. There are two to four active red-tailed hawk nests and two to three active golden eagle nests annually on or near the tracts. There are from four to eight active owl and kestrel nesting pairs, respectively, on or near the tracts each year.

Of the other nesting raptors, there are on the average, one pair of marsh hawks (*Circus cyaneus*) nesting in the shadscale, one pair of prairie falcons (*Falco mexicanus*) nesting in the cliffs west of Evacuation Creek, and one to two pairs of Cooper's hawks (*Accipiter cooperii*) nesting in trees and crevices along the White River.

Long-eared owls (*Asio otus*) nested along the river corridor in 1975 and were present in the winter of 1976. None have been seen since then. Turkey vultures (*Cathartes aura*) were observed along the White River but no nests were located. Sharp-shinned hawks (*Accipiter striatus*) may nest in the uplands, but sightings were so sporadic that this raptor is considered a transient. The only other possible nester is the peregrine falcon (*Falco peregrinus*), discussed below.

Winter residents on the tracts are the goshawk (*Accipiter gentilis*), the rough-legged hawk (*Buteo lagopus*), and the bald eagle (*Haliaeetus leucocephalus*). These three raptors are found primarily along the White River, although the rough-legged hawk, and on occasion the bald eagle, will forage in the nearby shadscale communities on either side of the river. Three transient raptors, which were seen on no more than two occasions, are Swainson's hawk (*Buteo swainsoni*) and the short-eared owl (*Asio flammeus*), both in shrub habitats, and the merlin (*Falco columbarius*), along the White River.

Threatened and Endangered Birds. One threatened and endangered bird, a whooping crane (*Grus americana*), flew south over the tracts on October 7, 1976, in the company of 300 sandhill cranes (*Grus canadensis*). The sandhill cranes migrate over the tracts in spring and fall. The whooping crane may have been from the Gray's Lake, Idaho experimental population. Since sandhill cranes seldom use the river corridor for a staging area, the occurrence of a whooping crane on tract is highly improbable.

Two threatened and endangered raptors occurred on and near the tracts. The peregrine falcon, which is listed as a transient, may have nested on or near the tracts in 1975. A male falcon was identified by different observers in April. In August a pair of adult falcons were feeding and soaring along the White River. They moved upriver and were joined by two other falcons; then the four flew out of sight in a side canyon. Due to the high bird abundance on the tracts in 1975, it is possible that the peregrines nested somewhere in the area. However, since no pairs were seen in April and no falcons were seen in June, this species is considered a transient. None have occurred on the tracts since 1975.

The bald eagle is a consistent winter resident along the White River corridor. From 3 to 10 eagles winter in the area. They also forage in the shadscale as far north as Bonanza, Utah, and along Evacuation Creek as far south as Watson, Utah.

2.5.4.5 Reptiles

Eleven species of reptiles (six lizards and five snakes) occur on or near the tracts. Reptile activity peaks from June through August with some activity in April and October. Lizard abundance remained fairly constant through five years. Snake abundance, which was low by comparison, peaked in 1975 and has since declined. The lizards are the most abundant of all reptiles on the tracts and have changed the least in terms of species and abundance of any vertebrate class.

2.5.4.6 Amphibians

Four amphibian species (two frogs and two toads) were found on the tracts. Their activity peaks in May and June. The leopard frog (*Rana pipiens*) is the most common frog along the White River, and it is limited to this habitat. The chorus frog (*Pseudacris triseriata*) is uncommon to rare along the White River. Both the Great Basin spadefoot toad (*Scaphiopus intermontanus*) and Woodhouse's toad (*Bufo woodhousei*) occur along the river and at

the ponds in Asphalt Wash. Abundance was rated as common for the spadefoot toad and uncommon for Woodhouse's toad. Peak years for amphibians were 1975 and 1976, and since then, observations have been sporadic.

2.5.5 AQUATIC SYSTEMS

The White River headwaters originate in primarily igneous schists and granite on the White River Plateau in Colorado. The geological character of the drainage basin changes rapidly to calcareous sedimentary rock as the river descends into Utah and the oil shale tracts. In this lower basin, soft marine sedimentary rocks and Pleistocene glacial deposits predominate. The resulting water quality reflects this change, with calcium carbonate waters of low dissolved solids found in the headwater streams and sodium-calcium-sulfate water high in dissolved solids found near the tracts.

The hydrologic regime can be divided into three major periods: fall and winter baseflow from groundwater infiltration, early spring runoff from the lower basin, and summer runoff from the upper basin. When superimposed on the easily erodable geology of the lower basin, this regime creates widely fluctuating water levels, sediment loads, and temperatures (Section 2.3.1) which largely govern the ecology of the aquatic system.

Aquatic macrophytes are nearly absent from the study area. They are probably limited by fluctuating water level and turbidity.

2.5.5.1 Periphyton

Periphyton data, though of poor quality, indicate rapid growth during periods of low turbidity in late summer. Growth continues until low temperatures and reduced photoperiod conditions occur. Other factors limiting periphyton may be the high silt load and concurrent scouring coupled with fluctuating water levels. Periphyton do not appear to be nutrient-limited. This pattern is typical of many desert streams.

There are two distinct periphyton communities in the White River. One occurs on submerged objects in shallow water subject to high rates of scouring and is composed mainly of the more rapidly growing "r"* selected filamentous green algae and diatoms. The composition of this flora varies with temperature, season, and discharge, among other factors. The second community occurs on more deeply submerged stones and is composed mainly of bluegreen algae. Limited light and lessened scouring in the deep water appears to be causal, favoring the slower growing "K"* selected bluegreens.

Flash floods are particularly important in Evacuation Creek, with local storms producing high water levels and high turbidity. The stream soon returns to normal flows (0.25 cfs), and the bottom structure is cleaned of algal growth. Given a clean substrate and fresh nutrient pulse, the periphyton community consisting of filamentous green algae and diatoms becomes quickly reestablished.

2.5.5.2 Phytoplankton

The phytoplankton, being mostly derived from the periphyton, is dominated by diatoms and shows a seasonal pattern reflecting this. Cell counts in the White River fluctuated from a low of 11,700 cells per liter in April 1975 to a maximum of 89,000 cells per liter in September 1975.

2.5.5.3 Macroinvertebrates

Macroinvertebrate (class Insecta) populations occurring in riffle areas of the White River fluctuated in average density between 53 individuals/m² in July 1975 and 2,630/m² in August 1976. These numbers indicate good

*r and K are symbols for two opposing selective forces defined by MacArthur and Wilson (Ref. 2-24). Organisms in a "competitive vacuum" (or extensively rarefied environment) put maximal amounts of matter and energy into reproduction and into the production of as many total progeny as possible as soon as possible(r); while in a "saturated" environment, organisms may put more energy into competition and maintenance and produce fewer offspring with more substantial competitive abilities (K). These strategies for reproduction are the two extremes of a continuum; no single species is completely "r" or completely "K" selected.

invertebrate production. Shannon-Wiener diversity* fluctuated between 1.9 and 2.4; diversity indices decreased downstream as noted by other studies on the White River. Species richness** fluctuated between 14 in July 1975 and 34 in August 1976. The riffle populations were dominated by members of the order Ephemeroptera. The populations occurring in pools fluctuated in average density between 63/m² in September 1975 and 2,800/m² in November 1974. Diversity values for pool populations ranged from 0.2 in November 1974 to 1.6 in April 1975. Species richness ranged from 4 in November 1974 to 20 in March 1976. The pool populations were dominated by members of the order Diptera. Members of the order Annelida were the dominant noninsect invertebrates.

In the sections of Evacuation Creek experiencing intermittent flow, the fauna is mostly restricted to insects that mature rapidly or are quite mobile. The dominant species of insect are in the orders Diptera and Hymenoptera. Members of the orders Ephemeroptera and Trichoptera may also be found in low numbers in a short portion of Evacuation Creek that flows through an aquifer near the Highway 45 bridge.

The macroinvertebrate community (primary and secondary consumers) is typical of many of the large rivers of eastern Utah. The river is probably a heterotrophic system, with primary dependence for energy on allochthonous input from the terrestrial environment. The species present represent most

*Shannon Wiener Index of Diversity:

$$H' = - \sum_{i=1}^m p_i \log_2 p_i$$

where p_i is the probability of occurrence at the i th species; or, $p_i = N_i/N_s$ where N_i is the number of species and N_s is the total number.

A low value for H' indicates high diversity.

**Species richness = number of species.

functional groups, with collectors dominating followed by scrapers and predaceous forms. The species present also represent organisms that are tolerant of broad environmental changes, which is consistent with the large fluctuations in the physical environment.

The macroinvertebrate communities demonstrate clumped distribution. This distribution coincides with the distribution of particular habitats and substrate types within the White River.

2.5.5.4 Vertebrates

The major aquatic vertebrates in the White River are a combination of endemic and exotic (i.e., introduced) species. Red shiners (*Notropis lutrensis*) are the most common, followed by roundtail chub (*Gila robusta*), flannelmouth suckers (*Catostomus latipinnis*), speckled dace (*Aphynichthys osculus*), fat-head minnows (*Pimephales promelas*), carp (*Cyprinus carpio*), and Eastern channel catfish (*Ictalurus punctatus*). Bluehead suckers (*Catostomus commersoni*), black bullheads (*Ictalurus melas*), green sunfish (*Lepomis microlophus*), and Colorado squawfish (*Ptychocheilus lucius*) are found in low numbers near the oil shale tracts. The exotics among the above include the Red Shiner, fathead minnow, carp, channel catfish, black bullhead, and green sunfish.

It has become increasingly apparent that endemic fish in the lower sections of the White River are being replaced by exotic fish, a pattern similar to that found in other western rivers. The Upper White River still has a dominant native fauna.

The species of exotic and endemic fish found in the area of the tracts use a large variety of physical habitats and could be characterized as opportunistic feeders. Several species are known to change habitat preference with different life history stages.

Two species of fish native to the White River Basin have been given either threatened or endangered status by the U.S. Fish and Wildlife Service. The Colorado River squawfish and the humpback chub (*Gila cypha*) are listed as endangered. The U.S. Fish and Wildlife Service is considering adding the bonytailed chub (*Gila elegans*) and the humpback sucker (*Ambloplites texanus*) to the threatened or endangered species list. The squawfish has been found in the White River near the Green River and upstream near Meeker, Colorado. These fish probably move upstream through the tracts during the proper flow conditions.

Due to pressure for additional water development in the Upper Colorado River Basin, the U.S. Fish and Wildlife Service started a study a year ago on the Colorado squawfish. The study is ongoing in the Colorado and Green Rivers only. The study objective is to develop, using in-stream-flow methodology, information on the critical habitat needs of this endangered species. The critical habitat information being developed will include flow needs, substrate preference, and effects of stream blockage and flow reduction. The study, sponsored by the Water and Power Resources Department, is projected for completion in July 1981.

The Fish and Wildlife Service is required to prepare an opinion concerning the effects of proposed projects on the endangered fish, and they have prepared one concerning the impact of the White River Dam Project. This was done as part of the dam's Environmental Impact Statement being prepared by the Bureau of Land Management. Their opinion was that the dam would put the Colorado squawfish in jeopardy.

Additional studies of the same nature have been proposed by the Fish and Wildlife Service for the White River. These are scheduled to begin upon receipt of funding and are expected to be completed at the end of 1981 with the final report published in the winter of 1982. They have decided

that their biological opinion will not be released until all the studies are complete, which should be in 1982. They suggest that all water projects in the Upper Colorado River Basin be postponed until studies are complete.

2.5.6 ECOLOGICAL INTERRELATIONSHIPS

2.5.6.1 Introduction

The climate of oil shale tracts Ua and Ub is arid; annual precipitation averages less than 10 inches per year, with most of the precipitation coming in the spring (Figures 2.5-8 and 2.5-9). Winters are cold and summers are hot. High evaporation and salinity limit water availability to organisms.

The White River creates a mesic habitat that can support a greater biomass than the surrounding upland. The river, then, effectively enriches the biota of this arid ecosystem by permitting species to exist that are not adapted to the desert environment. This is especially true of animals with enough mobility to range through all of the habitat types.

The upland areas are characteristic of desert-arid grassland communities. Organisms, other than those associated with the riparian areas, are adapted to arid environments and live within the constraints defined by the climate. These constraints include:

- Low water supply
- Unpredictable duration and intensity of droughts
- High light intensity
- Extreme diurnal and seasonal temperature variation
- High vapor pressure deficit (drying power of the air)

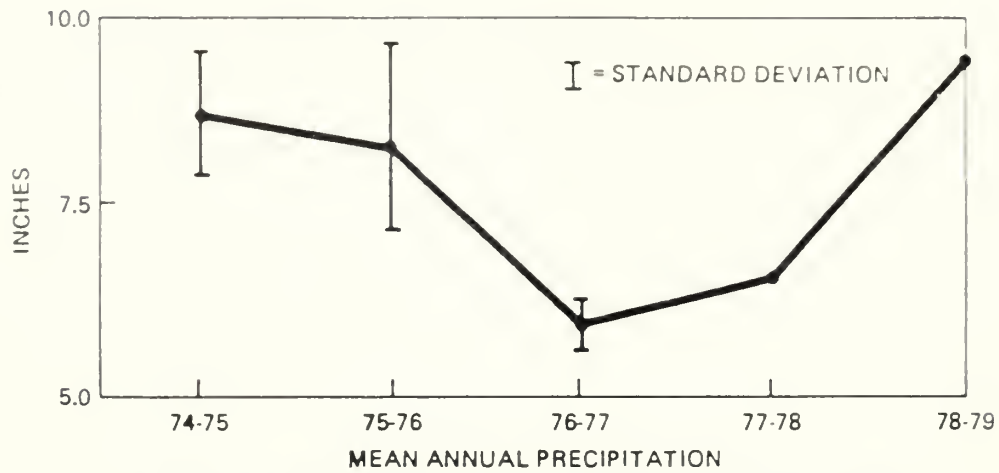


Figure 2.5-8 MEAN ANNUAL PRECIPITATION FOR WATER YEARS 1974-75 TO 1978-79

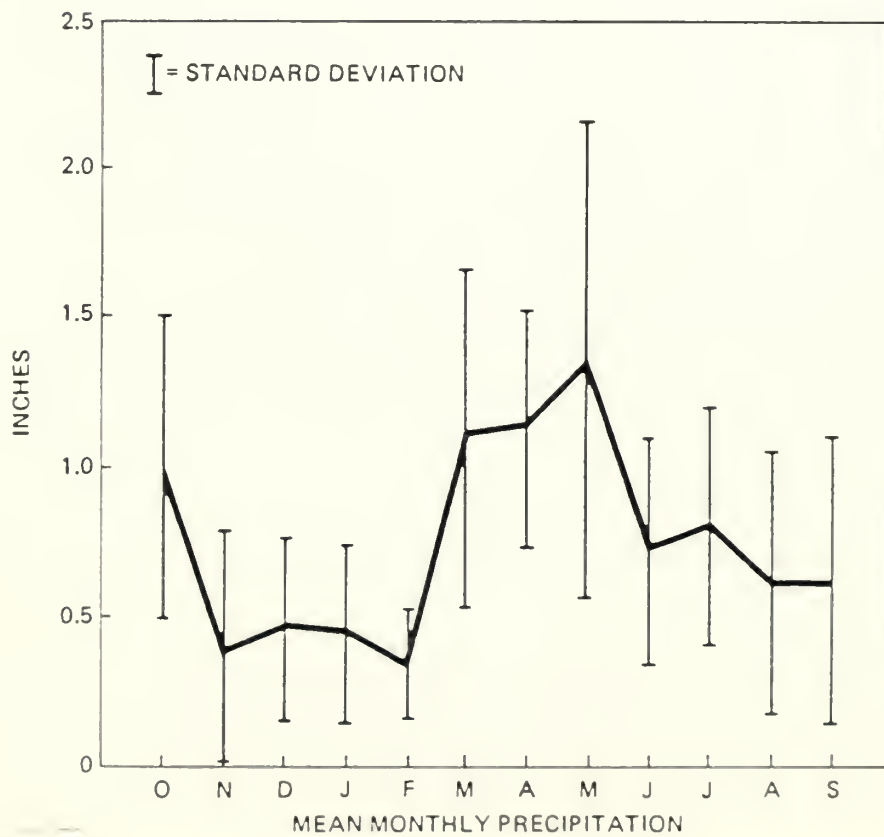


Figure 2.5-9 MEAN MONTHLY PRECIPITATION FOR WATER YEARS 1974-75 TO 1978-79

- Loose substrate
- Open terrain (little vegetative cover)

The environment on the tracts is that of a water-controlled ecosystem with infrequent, discrete, and largely unpredictable water inputs. Superimposed on this system is a river. The riparian system has an oasis effect, providing habitat for organisms that could not normally occur in arid areas. The controlling environmental factors in the riparian communities are based on the dynamics of the river flow.

2.5.6.2 Ecosystem Relationships

An ecosystem receives energy from the sun and materials and energy from the biogeochemical cycles. It processes these materials and discharges outputs, which then enter the larger biogeochemical cycles and affect neighboring ecosystems. In other words, the outputs of one ecosystem become the inputs of another. Activities within an ecosystem are largely governed by the nature of the inputs. Man affects the structure and function of an ecosystem by conscious or inadvertent effects on inputs. Similarly, man can have major effects on the nature of ecosystem outputs by his conscious or inadvertent manipulation within the ecosystem (Ref. 2-25).

Inputs can be meteorological, geological, and biological. Meteorological inputs include solar energy, precipitation, gases, and airborne solids; geological inputs are from stream and groundwater as well as from gathering of parent material; biological inputs are from deposition of plant and animal material originating outside of the ecosystem.

The ecosystem on the oil shale tracts is composed of terrestrial and aquatic subsystems, and these are intimately connected via water, energy, and nutrient flows. Organic and mineral materials are carried from the terrestrial subsystem to the aquatic subsystem in surface water, groundwater, and litter fall. The chemical content of water falling on the land in

precipitation is altered as it passes through the terrestrial subsystem. The aquatic subsystem influences the terrestrial by increasing the amount of solar energy incorporated into organic compounds, i.e., increased primary production. These compounds are transported through terrestrial systems by the river and are available to the terrestrial food chain.

Ecosystem outputs fall into the same general categories as the inputs. Meteorological outputs consist of gases and solids added to the atmosphere; geologic outputs include materials carried by surface and subsurface drainage and deep seepage as well as colluvium; biologic output is that exported by living organisms (e.g., algae transported downstream, insects leaving the area, and animals hunted and transported away).

Human activities associated with oil shale development in the area will affect ecosystem inputs, outputs, and interrelationships. Their effects are primarily related to air and water quality, but climatic alterations are also possible. Within the ecosystem, human effects can be caused by mining and industrial development, recreation activities, and increased human population.

In the following sections, the terrestrial and aquatic subsystems are examined in closer detail. Specific inputs and outputs are identified, and the structural components of each system are described. Processes acting within and between components are discussed.

2.5.6.3 Terrestrial Subsystem

The components of the terrestrial subsystem include plants, soils, vertebrates, and invertebrates. Data were collected on these components during the baseline and interim environmental programs, as follows:

- Plants
 - Vegetation types
 - Vegetation characteristics
 - Yearly production indices

- Soils
 - Soil types
 - Physical properties
 - Chemical properties
 - Soil water
 - Microbiology
- Vertebrates and invertebrates
 - Species composition
 - Abundance
 - Habitat preference

Each of these components interacts with the others as a result of predation, competition, and nutrient cycling. The vertebrate and invertebrate components are both consumers and affect the plant and soil components in a similar way.

Meteorological inputs to this subsystem include precipitation, solar radiation, and wind (including airborne materials). The system is ultimately powered by solar radiation through photosynthesis, heat flux, and seasonal change. Year-to-year changes in plant productivity and animal abundance in arid climates are determined by precipitation. The system may be viewed as being water-controlled. Precipitation comes in discrete, infrequent, and unpredictable events or "pulses" which are of short duration relative to the dry periods. Figure 2.5-8 shows the yearly mean and standard error of precipitation on the oil shale tracts. The low-water years of 1976-77 and 1977-78 were also years of low primary production. Monthly precipitation patterns are more predictable (Figure 2.5-9). Spring usually brings the most precipitation, followed in order by fall, summer, and winter. The pattern of the precipitation events, in conjunction with soil structure and topography, determines the composition and spatial arrangement

and productivity of the vegetation. Vertebrates and invetebrates respond to these vegetation parameters. Wind affects vegetation patterns by seed and soil particle transport and by its effects on evapotranspiration.

Geological inputs relevant to the terrestrial subsystem are weathering, and alluvial and colluvial deposition. These affect the plant community through availability of nutrients and soil structure. Decomposers are affected by the chemical and physical properties of the resulting soils and plant communities.

Biological inputs are photosynthesis by plants and imports into the system by animals themselves. This includes transport of propagules, waste products, and the animals themselves. These inputs are rather small in systems unaffected by man. However, agricultural practices can result in considerable input.

Relationships of the organisms within the system are generally associated with growth and survival. Specific processes will be detailed in the following sections.

System outputs constitute those materials passed on to other ecosystems. Important meteorological outputs include nitrogen, airborne particulates, and pollutants resulting from human activities. Geologic outputs are those materials transported by water. Biologic outputs include exports by animal activities (e.g., transport of materials by birds and large mammals and human use of plant and animal materials).

Plants. Deep-rooted perennial plant species such as shrubs are affected primarily by the amount of precipitation during the fall and winter. Measurements of sagebrush leader length taken in September, which indicate the favorability of conditions for perennial growth, are closely related to total precipitation from October through March (Figure 2.5-10). One reason for this relationship is that deep-rooted perennial species such as sagebrush rely on stored moisture in the deeper soil layers to continue

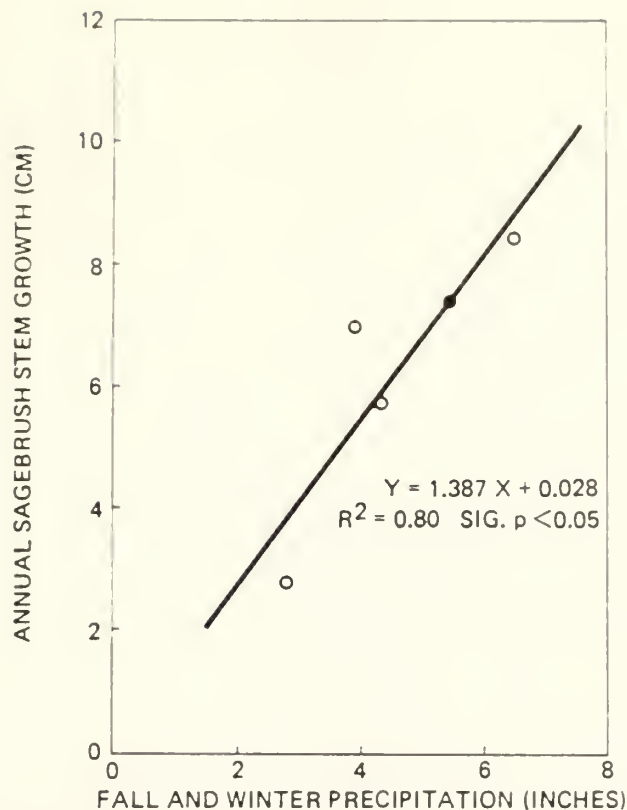


Figure 2.5-10 MEAN ANNUAL SAGEBRUSH STEM GROWTH RELATED TO FALL-WINTER PRECIPITATION

growth throughout the summer. Precipitation falling during the warm months of late spring and summer is quickly lost by evaporation and the transpiration of annual plants, and never reaches the deeper soil layers. However, snow melting in the early spring and rainfall during the cooler months of the year are not lost and are able to infiltrate deeply.

In contrast to shrubs, herbaceous (usually annual) plant species have shallow root systems and can tap soil moisture only down to about 15 centimeters. Thus, they are unable to use deep soil moisture stored from the cool months of the year and must rely on rainfall during the spring growing season. Total rainfall from April through June was shown to be the most important factor influencing herbaceous productivity (Figure 2.5-11), but the evenness

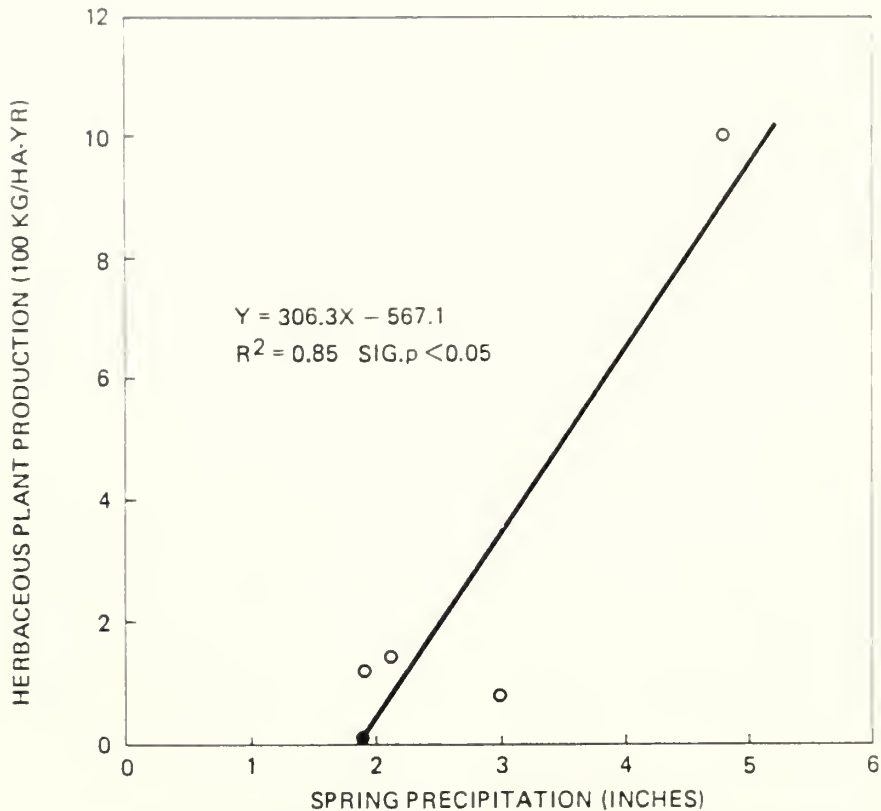


Figure 2.5-11 MEAN ANNUAL HERBACEOUS PLANT PRODUCTION
RELATED TO SPRING PRECIPITATION

of spacing of rainstorms during the critical growing period can also have an effect. The yearly contribution of plant biomass to soil organic matter is correspondingly variable, and this influences the amount of nitrogen available for growth of plants in subsequent years. In contrast, perennial species, especially shrubs, maintain a generally consistent biomass and presence throughout the seasons and from year to year, thus acting as a stabilizing influence on animal populations and on soil organic matter. Any development effects that have an adverse influence on shrubs would have a high probability of adversely affecting other components of the ecosystem.

While rainfall amount and timing cause temporal fluctuations in plant growth and thus in animal populations, the depth, water-holding capacity, and salinity of soils influence the spatial distribution of plant communities on the tract and the average productivity of those communities.

Riparian vegetation, the most productive of the vegetation types, is found only in areas adjacent to water and on moist soils. The soils of the site that are moist enough to sustain this type of vegetation are W soils and D soils. The W soils are deep, imperfectly drained, and form in silty alluvium adjacent to the floodplain of the White River. All of the W soils mapped at the site support riparian vegetation. Riparian vegetation also occurs along Evacuation Creek where D soils are moist enough.

Greasewood vegetation, the next most productive vegetation type, occurs exclusively on the D soils at the site. D soils are the deep, sandy loam soils forming in alluvium. They occur in the relatively narrow drainages below steeply sloping soils and rock outcrops. The soil has a relatively high water-holding capacity. The correlation between areas of D soils and areas of greasewood vegetation is the closest of any of the soil-vegetation relationships at this site.

The upland soils at the site are similar to one another, but support a variety of vegetation groupings, all of which have low productivity. The juniper type is found at the high elevations on the thin sandy soils — As, Bs, and F soils — that have low salinity and low water-holding capacity. These are shallow and very shallow sands, sandy loams, or loams. The eastern limits of juniper roughly coincide with the limits of these soils along the west side of Evacuation Creek. However, juniper is also limited by altitude requirements and may not always be found on these soils; the thin sandy soils that are below the juniper-vegetation limits to the north and to the west are dominated by big sagebrush.

The A and B soils have formed on the Green River Formation. Very shallow loam soils, they are less sandy, more saline, and have a higher water-holding capacity than the upland soils found in the Uinta Formation. The vegetation on these soils is exclusively the shadscale-black sagebrush type. The shadscale-black sagebrush type is also found on the sandy soils (As, Bs, and F) that occur north of the White River.

Soil characteristics influence the type of vegetation that a site can support, and vegetation, in turn, influences the soil characteristics of the site. Each shrub or tree acts as a barrier to the movement of soil particles and litter by wind and water erosion. As it drops leaves, it builds up material around its base, improves the moisture-holding capacity of the soil, increases nutrient availability, stimulates the activity of invertebrate and microorganisms, and prevents erosion. In the soil thus improved, the original shrub flourishes and other plants, both herbs and woody species, take root and grow. These additional plants, in turn, improve the soil still more. Thus, a small, self-perpetuating island of biological activity is established.

Soils. The paragraphs below discuss the physical and chemical properties of the soils in Tracts Ua and Ub and the soil microbiology.

Physical and chemical properties. The substrate of the tracts consists of exposed bedrock, broken pieces of rock of various sizes, and soil. The percent coverage of each has not been precisely determined, but the nonsoil components of the substrate are known to be substantial. Most of the upland soils are shallow and poor from an agronomic point of view. They are low in organic material and retain moisture poorly. The only soils with any depth are under the larger plants, in valley bottoms, and along the watercourses.

Several factors combine to form deep soils in most areas. The interaction of occasional, intense rainstorms, annual spring runoff, wind, and hilly topography of sandstone bedrock results in heavy erosion. The erosion, increased to an unknown degree by livestock, tends to cause continual sloughing of soil in the interstices between the larger plants, especially on the steeper slopes. The condition perpetuates itself, since few plants that could reduce erosion are able to grow in the eroding areas. From an agronomic point of view, the lack of moisture and the poor soils must be considered major limiting factors to the potential biotic productivity of the tracts.

Soil microbiology. In the desert, as in all ecosystems, microorganisms play a pivotal role by decomposing organic matter and making nutrients available in a usable form for plants. Microbial activity is low on the tracts, which corresponds to low nutrient availability and plant productivity relative to more mesic ecosystems.

The driving variable for microbial activity in arid ecosystems is soil moisture, which is expressed directly by limiting microbes, and indirectly by limiting plant primary production (and subsequent microbial substrates).

During the baseline study, microbial numbers, activities, and abiotic factors were sampled. Data were evaluated by stepwise multiple regression to determine the most influential relationships. Because many factors influence microbial dynamics concurrently, simple cause-and-effect relationships are not apparent. However, some relationships are discernible from the data. Statistically significant relationships were found between microbial dynamics and soil moisture, soil organic material, and soil temperature.

Microbial activities are limited by low and high temperatures. During winter, when the snow cover is insufficient to insulate the ground, soil temperatures drop too low for biological activities. Summer soil temperatures, at least on the surface, exceed 100F. These high temperatures, combined with moisture stress developed from the resulting high evaporation, limit microbial activities. Dehydrogenase and respiration have significant inverse relationships with soil temperature during the growing season. Soil temperature accounts for less variance in microbial numbers and activities than do soil moisture and organic carbon. Microbial activity is usually highest during the spring, but high activities occur during the summer in wet years (e.g., 1975).

Water, the driving variable in desert systems, affects microbial dynamics directly through soil moisture and indirectly by affecting plant productivity and subsequently the input of organic material into the soil. Soil

respiration is significantly correlated to soil moisture. Because respiration is an indicator of overall soil activity, this suggests that soil moisture generally limits biotic activity in the soil when temperatures are favorable. The groups of microbes that are most affected by soil moisture are the bacteria (aerobic, anaerobic) and Streptomyces. F-tests indicate that soil moisture effects on aerobic bacteria and Streptomyces are significant. Anaerobic bacteria become active when the O_2 concentration in the soil decreases below some critical level. Fungi are secondarily affected by soil moisture. Water affects the seasonality of microbial dynamics in that spring is the time of year when precipitation is highest (Figure 2.5-8).

Plant productivity affects microbial dynamics by being the major source of soil organic material. Fungi, because they are primarily responsible for plant residue decomposition, are most strongly affected by soil organic material. Fungal populations show a direct correlation with soil organic carbon. Dehydrogenase activity is also directly related to organic carbon. Of the microbial groups sampled, fungi are most closely related to dehydrogenase activity.

Microbial activity varies spatially as well as temporally, and the greatest activity occurs beneath the canopy of shrubs where the organic carbon content and moisture-holding capacity of the soil is high. Table 2.5-7 shows dehydrogenase activity, an indicator of overall soil microbial activity, averaged for 1976 for the sagebrush-greasewood and juniper vegetation types.

As shown, activity was significantly higher in the soil beneath the plant canopies than in the interspaces, and the average organic carbon content beneath the canopies was 1.09 percent, which was significantly higher than the 0.81 percent organic carbon content found in the interspaces.

Table 2.5-7

MEAN DEHYDROGENASE ACTIVITY IN 1976
(mg formazan/gm dry soil)

Item	Samples from Shrub Canopy	Samples from Interspaces
Vegetation Type		
Sagebrush-greasewood	0.11	0.04 ^(a)
Juniper	0.31	0.14 ^(a)
Average Organic Carbon Content	1.09	0.81

(a) Significant at $p < 0.01$; T-test.

Microorganisms have a major role in making nutrients available in usable form, and since their activity is concentrated in soil beneath the canopies, the nutrient availability is greatest in these areas. These nutrients encourage plant growth, in turn cause more organic matter to be returned to the soil, and further increase microbial activity and nutrient availability. Thus, the island effect discussed in the section on vegetation is reinforced.

Vertebrates and Invertebrates. Terrestrial vertebrates and invertebrates are more important in ecosystems than their relative biomass may indicate. Animals usually constitute only 10 to 15 percent of total biomass for most kinds of terrestrial ecosystems, but they act as regulators of the energy flow that passes primarily from the plants to the decomposers. By influencing the rate and the manner by which energy is transferred, they are responsible, in many cases, for spatial and temporal patterns of organisms.

Conversely, the animals reflect the nature of the vegetation and soil components, as they rely on plants and soil for food and shelter. For the tracts, we have sufficient data to relate vertebrate diversity and abundance to some plant and soil characteristics.

Diversity and abundance within the bird community result from the structure and productivity of the plant community. By comparing mean bird abundances and species richness (number of species encountered) for the different habitats, it can be seen that abundance and richness increase linearly from shade-scale to juniper to sagebrush-greasewood to riparian areas (Figure 2.5-12). This relationship can be attributed to the increasing structural complexity of the vegetation. The same figure shows the change in bird abundance and richness through the seasons, which can be related to the vegetation. During the growing season, plant development, and consequently insects living on the plants, reaches its peak in June and declines thereafter owing to decreasing moisture availability.

Mean annual bird abundance does not relate directly to plant productivity. The closest relationship is between mean annual bird abundance and the total annual precipitation from the water year (Figure 2.5-13). This is because most bird species rely on insect food at some time of the year, and insect production is related to annual precipitation. Annual bird abundance, then, can be interpreted as the result of both annual plant and

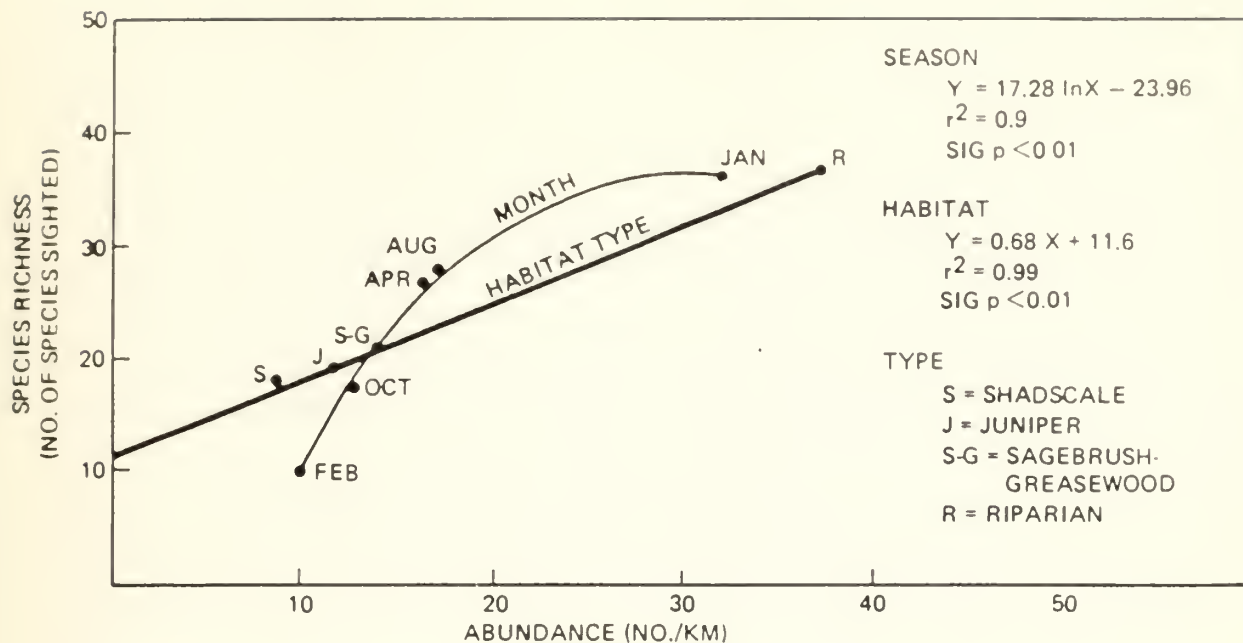


Figure 2.5-12 MEAN ANNUAL AND MONTHLY BIRD SPECIES RICHNESS AND ABUNDANCE FOR THE FOUR HABITAT TYPES, 1975 TO 1979

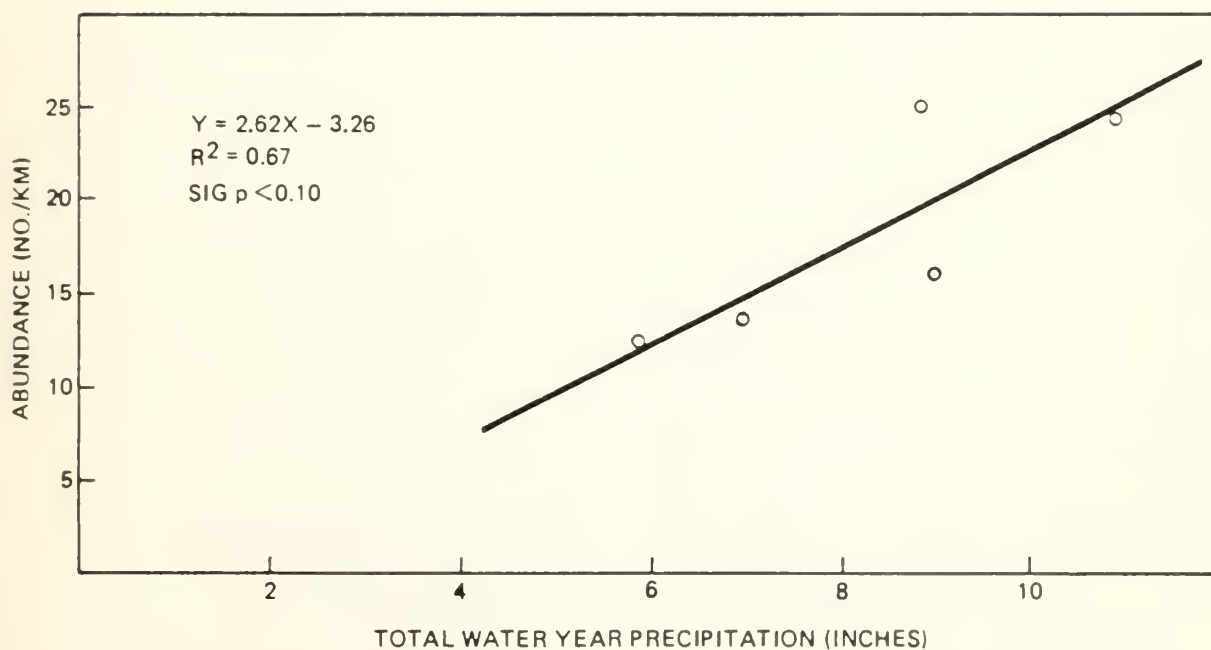


Figure 2.5-13 MEAN ANNUAL BIRD ABUNDANCE RELATED TO TOTAL PRECIPITATION, 1975 TO 1979

insect production. Birds can be used as a valuable tool for monitoring, once the relationship of bird abundance in insect productivity is established.

Diversity and abundance within the rodent community result from soil structural characteristics and productivity of the herbaceous plants. Because rodents are intimately associated with soil through feeding and burrowing, soil structural characteristics affect the rodent community. Rodent species richness and density are related to soil infiltration rates and percent moisture, respectively (Figure 2.5-14).

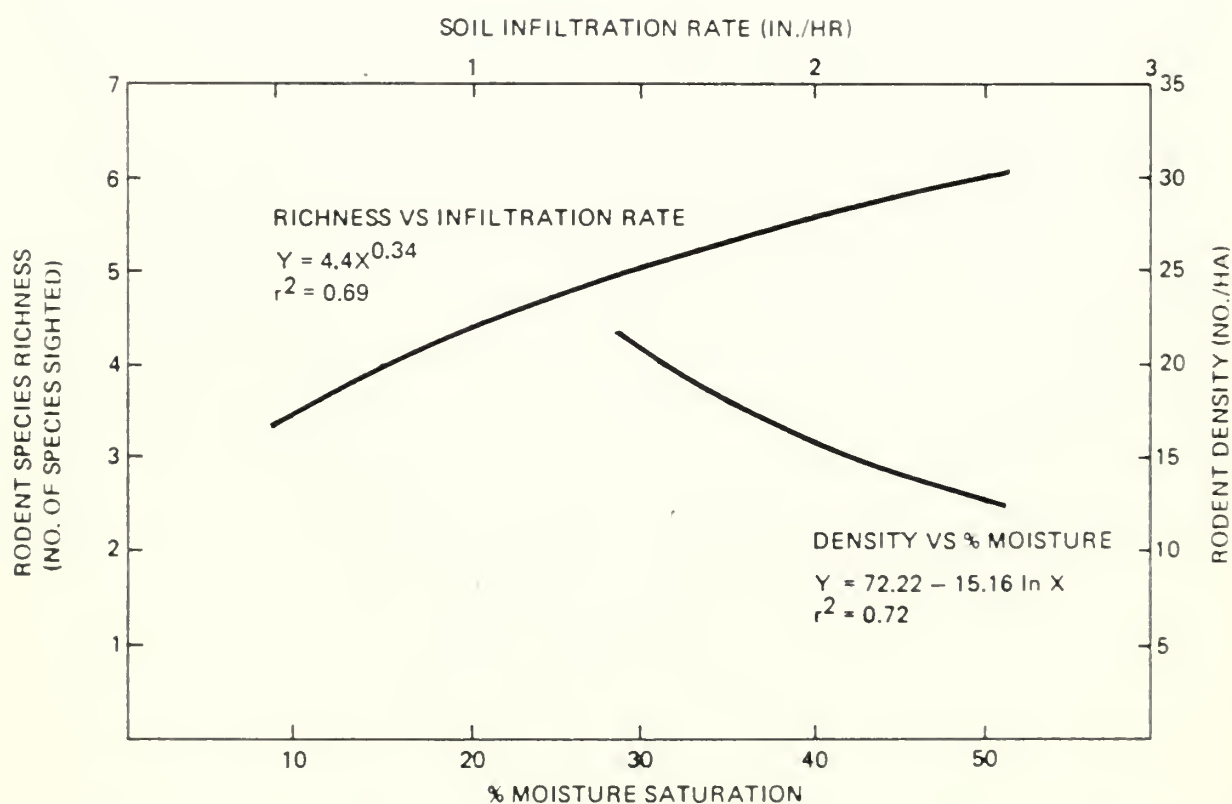


Figure 2.5-14 RODENT DENSITY AND SPECIES RICHNESS RELATED TO SOIL INFILTRATION RATE AND PERCENT MOISTURE AT SATURATION OF THE SOIL

Soil water characteristics are the result of particle size, chemical composition, density, pore space, and organic matter. The measurement of infiltration rate and water-holding capacity, therefore, integrates many physical characteristics of the soil. For burrowing rodents, soils that are loose, but not so loose that burrows collapse, are favored. These soils have high infiltration rates and low water-holding capacities.

Annual rodent abundance is related to the production of annual and perennial herbaceous plants (Figure 2.5-15). Seeds from these plants form the basis of rodent diets, although other foods may be used seasonally. The response of the rodent populations to changes in herbaceous plant productivity in a given year will result in high rodent populations in the following year. Seed production from the woody plant species is undoubtedly important to rodents;

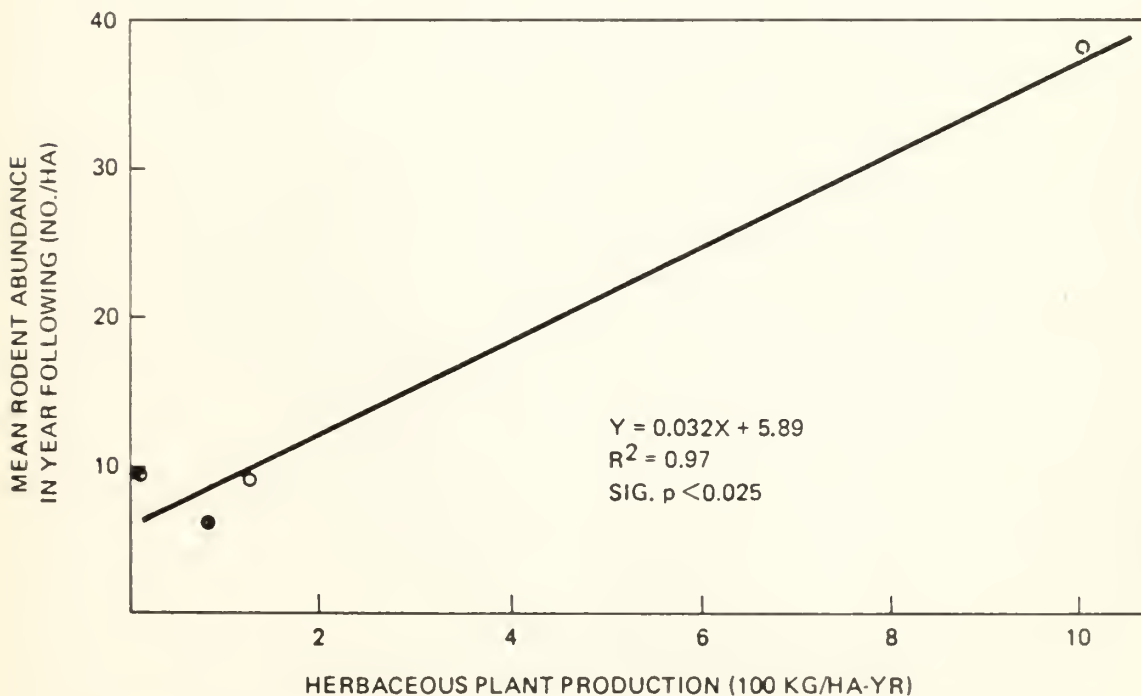


Figure 2.5-15 MEAN RODENT ABUNDANCE RELATED TO MEAN HERBACEOUS PLANT PRODUCTION (PRECIPITATION OF A GIVEN YEAR IS COMPARED TO THE FOLLOWING YEAR'S RODENT ABUNDANCE.)

but because sagebrush leader growth is not an index to shrub seed production, there is no way to evaluate the effects of shrub seed production on rodent populations.

Vertebrates affect and are affected by invertebrates. Diversity, abundance, and heterogeneity of many vertebrate species result from the abundance and species composition of the invertebrates.

Populations of insectivorous birds that inhabit the tracts during the growing season undoubtedly respond to insect abundance. Many seed-eating species of birds and mammals eat insects at certain times of the year. This is especially true of birds during the time they are rearing their broods. At this time, high-protein foods are important for growth and development of the young. Invertebrates act as parasites and disease vectors and in many cases significantly affect vertebrate populations. However, the importance of the above relationships relative to the vertebrate populations on the tracts would need additional data for full verification.

Vertebrates interact with the soil component in several ways. Many species use the soil for shelter, and they usually get their food from the soil as well. Of particular importance is mycophagy. Some species, particularly rodents, eat fungi at certain times of the year, and in so doing, disperse the fungal spores. This can be very important in establishing mycorrhizal associations in disturbed areas. Also of importance are pathogenic relationships between soil microorganisms and vertebrates.

While eating and living on plants, invertebrates affect plant spatial distribution and reproduction. Invertebrate herbivores are usually quite specific with respect to food items. Consequently, the structure of the plant community directly influences the structure of the invertebrate community. Activities and resource requirements of pollinators directly affect the reproduction of many species of plants. Also, invertebrates are often

vectors of plant pathogens. However, because of a lack of data on invertebrate diversity and abundance, these relationships cannot be evaluated.

Soil invertebrates are important in the decomposition of dead organic matter. The processing of detritus in many communities is based on a collaboration of animals and microbes. Some animals feed directly on dead plant material, digesting part of the organic material as it passes through their guts. Other animals do not use the plant tissue for food; they eat the microbes that grow on the plant material. At the same time, these animals physically break up the plant tissue into smaller particles that can be more effectively attacked by microbes. Decomposition of organic material is slowed greatly if animals are removed or excluded from the soil.

2.5.6.4 Aquatic Subsystem

The aquatic subsystem is made up of the physical component (water, stream bottom, etc.), algae, microbes, vertebrates, and invertebrates. The relationships between these components is governed by the driving variables that are the inputs to the system (meteorologic, geologic, and biologic).

Within the constraints set by the physical environment, a set of complex biological relationships exists. Each biotic component and the functions between them are determined by two important biological inputs to the system: in-stream photosynthesis and the introduction of organic debris (e.g., leaf litter) from the terrestrial system. The relative amounts of these establish the trophic dependence of the system. The White River's large seasonal inflow causes removal and/or lowered production of the primary producers (algae). Maintenance of the two biological inputs is essential to provide a stable food base for the animal communities.

Though data for the White River and its tributaries are insufficient to establish quantitative structural and functional relationships, they can be characterized qualitatively. This characterization is necessary to establish a framework within which the long-term effects of oil shale development may be predicted, monitored, and controlled in order to maintain the complex biotic and abiotic structure of the aquatic environment.

Physical Environment. Major stream systems that flow through arid regions usually have their origins in distant places of higher elevation that receive comparatively high, persistent, or seasonal precipitation. The White River system is, in general, similar to other large Intermountain West rivers in that meteorologic and geologic inputs are dominant.

The major meteorological/geologic input is from spring melting of lowland snowpacks (lower basin runoff). This represents only a small portion of the spring runoff, but the nutrient content of the source water is high, which could stimulate algal production due to the nitrogen and phosphorus levels in the White River. The second major input is the snowmelt from high elevations (upper basin runoff). The volume of water is extremely large and causes extensive dilutions and sediment transport in addition to importing organic materials from upstream. The third major input is from periodic, unpredictable storm events. Because of the nature of desert drainage basins, tributaries may contribute substantial amounts of water on a short-term basis during storm events. The major impact of these events may not be the actual water contributions but the quantity of silt and organic debris added to the river system. In the White River system, this third input is most important during baseflow (after runoff) in late summer.

Discharge affects the biota of the stream system by modifying the habitat (substrate). The habitat is modified by changes in:

- Velocity and turbulence
- Sediment transport
- Solar radiation
- Temperature
- Water chemistry

Velocity and turbulence shift and restabilize the bed configuration. This process produces tremendous grinding action that may physically damage animals, dislodge periphyton (algae) communities, and modify pools, runs, and riffles. Periods of high discharge or storm events will produce greater habitat modification than baseline flows. The stability of the substrate is dependent upon current velocity and relates to the organisms that use the benthic regions for attachment. The current-determined substrate size also determines the size of organic particles trapped within pore spaces. The configuration of canyon walls or large boulders may be important in creating refugia by deflecting currents in a predictable manner.

Sediment transport, light, and velocity are interactive in affecting the aquatic biota. For example, increases in turbidity without changes in current velocity cause different responses by periphyton communities, depending upon the amount of available light; changes in water velocity alone have been shown to change periphyton production. Under identical flows, periphyton communities grown under high light are more easily scoured than communities grown under low-light conditions. Sediment influences primary producers by altering light intensities, nutrient levels, substrate types, and species composition. Overall, increased levels of suspended sediment reduce light intensity and limit photosynthesis; however, the presence of associated nutrients may ameliorate this effect to some extent. Sediment influences macroinvertebrates by

modifying habitats and inducing movement out of areas with high rates of decomposition. Sessile organisms can be drastically reduced by burial. Recovery by mobile invertebrates is rapid, following the resumption of normal conditions. Recovery depends on how the habitat was modified, the substrate preference and life history of the organisms, the type of refugia available, and the mode of migration.

Sediment affects fish by indirectly increasing mortality, altering rates of reproduction, and modifying rates of growth. Suspended sediment does not appear to be lethal for adult or juvenile fish but may reduce disease resistance and damage gill tissue. Habitat modification, particularly the loss of cover for juvenile fish and removal of suitable spawning sites, may reduce certain fish populations. The endemic fish in the White River are uniquely adapted to overcome the naturally high turbidity of the system.

The amount of solar energy entering the White River varies with season and with discharge-related sediment load. The light regime is important in attempting to relate the effect of changes in other physical characteristics, because the light climate of each major habitat type may explain the benthic community changes in relation to flow, silt load, temperature, and chemistry. Light and light-related factors may also help explain the activity patterns of several endemic fish species and reproductive cycles. Turbidity values in the White River fluctuate through large seasonal cycles. They fluctuated from 0 Jackson Turbidity Units (JTU) to 1,000 JTU during the baseline period.

Because most aquatic organisms are ectothermic, temperature is extremely important in community metabolism. Wlosinski indicated in the validation of his Desert Stream Ecosystems Model that stream temperature was the most important physical parameter affecting the community metabolism (Ref. 2-26). Temperatures in the White River fluctuate seasonally through a range of 0C to near 30C.

Water chemistry data indicate that concentrations of the essential micro-nutrients nitrogen and phosphorus do not appear to be limiting primary production in the White River.

Algae. Algae are the lowest members of the aquatic food chain and are the only food base generated within the river system. They are an important food base for many of the aquatic invertebrates, particularly the individuals belonging to the groups of collectors and scrapers. In addition, the benthic algae community serves as a food base for some fish, such as the bluehead sucker and channel catfish.

Two important periphyton communities coexist within the White River. The riffle community of green algae and their associated epiphytic diatoms is the more diverse community and occupies the shallow, higher velocity, high-light-fluctuating water zone with stony substrate. The pool community of blue-green algae is less diverse and occupies large boulders in the deeper pools with lower light levels, lower velocities, and relatively stable conditions. Thus, the communities are separated spatially within the system by water depth, substrate type, current velocity, and light. It has been suggested by several authors that current speed actually determines the major species composition, although there is evidence to suggest that species specific trends occur in smooth versus textured surfaces. Substrate stability is also important with smaller, faster growing forms, such as diatoms occupying the small, loose, unstable substrates.

Temporally, the communities are separated by the action of components of the physical environment. Diatoms and green algae are favored by cool temperatures, higher light, and more rapid growth rates. They are more subject to nutrient limitation, however, in that they lack the ability to fix nitrogen as can blue-green algae. These environmental factors, which are seasonally cyclic and occur in a regime of highly fluctuating discharge rates and accompanying silt loads, prevent the communities from following a seasonal succession sequence that one would find in a lake or more constantly

flowing nonturbid stream system. Owing to the summer scouring, the slower growing blue-green algae that might be favored by the warmer temperatures are not able to colonize the shallow riffle areas as fast as green algae and diatoms, so they are displaced by the more rapidly growing groups. Thus, the communities remain separate in space and time.

Though the standing crop of riffle periphyton may fluctuate more seasonally than the more stable blue-green pool community, productivity in the riffle community should be higher because of the higher light, nutrient flux, and availability of fresh substrate created by continual sluffing of periphyton. If the seasonal flow fluctuations were inhibited, a sequence leading to dominance by blue-green algae and a lowered overall productivity amplified through the trophic levels (food chain) might be observed.

The phytoplankton appear to be derived from sluffing of the periphyton and represent export from the substrate with little in-situ generation of phytoplankton biomass. However, data are insufficient to determine if this relationship holds.

The animal communities, in addition to using the algae for a food source, enhance algal productivity by regeneration of nutrients. Through their grazing activities, they remove a portion of the algal populations, creating substrate for more algal colonization and growth.

Microbial Community. Little specific information is known about the microbiological components of the White River ecosystem. Their role, though not quantified, is extremely important. All organic inputs to the stream ecosystem from in-stream photosynthesis and terrestrial litter fall are ultimately mineralized by the microbial community. Bacteria and fungi play a variety of roles in this system. Bacteria play an important role in oxidizing hydrocarbons in the nitrogen and sulfur cycles, and in ultimately mineralizing all organic inputs so that they become available to the plant (algae) communities as nutrients once again.

The rate of degradation of this detritus depends upon detrital refractility, surface:volume ratio, and environmental variables such as temperature and pH, which control enzymatic rates.

The relationship is complex between the microorganisms, their food source, and the macroinvertebrates. In general, microorganisms attached to their food are consumed by the collectors and shredders (i.e., detritivores), and particles ingested are broken down into smaller sizes. During the process, microbes are stripped off and digested, which functionally breaks the large particulate detritus into smaller fractions. The process is then repeated by a new set of organisms.

Invertebrates. The impact of physical-chemical factors on the distribution of macroinvertebrates is usually indirect, with the major controlling factor being the quantity or quality of food. In general, faunal elements are adapted to the particular environmental conditions, including stream size, substrate, temperature, velocity, oxygen concentration, light intensity, water hardness, and alkalinity. Distribution patterns are influenced by water movement and the nature of surface available for colonization (sediment particle size). As stated previously, velocity and turbulence limit the range of particle size and thus macroinvertebrate distributions. Food is the ultimate determinant of macroinvertebrate distribution. In nonperturbed running waters, as with the algae, there are two distinct communities among the invertebrates: a riffle community and a pool community. The riffle community is more diverse and is dominated by members of the order Ephemeroptera. The pool community is less diverse and is dominated by members of the order Diptera.

The riffle habitat is a structurally and environmentally more heterogeneous environment than the pool habitat, with high pulses of in-situ primary production. This diversity of habitat creates more available niches for colonization and through its complexity provides buffering against perturbations for which the system is adapted. The riffle habitat is more diverse, having more trophic modes than the pool habitat.

In both habitats, collectors predominate, indicating that the system is highly dependent upon allochthonous inputs (dead leaves, branches, etc. from the terrestrial system). In riffles, scrapers are next in importance. Their presence indicates a better balance between heterotrophy and autotrophy for the riffle communities. In pools, scrapers are very low in numbers, with predaceous forms (engulfers) the second most important group. This indicates that in pool habitats the trophic dependence is primarily on detritus.

Different species or groups avoid competition by spatial separation within the same habitats. In addition, temporal variation in life history patterns reduces competition. Though members of the Ephemeroptera are dominant throughout the year in the riffles, the Plecoptera increase in numbers during winter and spring when Ephemeropterans are on the decline. As many of the Plecopterans are predaceous, this decline could be due to predation or emergence. Like Ephemeropterans, Trichopterans are mostly collectors and scrapers and cycle in abundance with them, probably because of similar trophic dependence and reliance on similar seasonal factors.

Vertebrates. Population data are unreliable, so only qualitative relationships with other biotic or physical parameters can be established. The species of fish inhabiting the White River in the vicinity of the tracts are adapted to warm, turbid waters, and most of the endemic species possess morphological characters that suit them for an environment with fast water and an unstable bottom.

In addition, the food habits of the fish could be characterized as opportunistic. The dominant species, including flannelmouth and bluehead suckers, have been found to feed primarily on algae and associated macro-invertebrates. The red shiners feed primarily on true flies but can be piscivorous.

2.5.6.5 Human Effects upon the Ecosystem

Any alteration to a given ecosystem component will affect other components. Presently, human effects on the ecosystem are associated with cattle and sheep grazing and mineral resources development. The general effects of these practices are removal of plant material and soil surface disturbance. These effects contribute to decreased plant cover and increased runoff.

Results of these and other human activities, such as construction of roads, dams, and bridges, are felt in the White River subsystem through increased silt loads and altered nutrient inputs during terrestrial runoff. Other human influences, such as salinity increases from withdrawal and reintroduction of irrigation water, could alter stream communities by reducing the number of organisms, decreasing production, and introducing species with different tolerance limits.

2.6 HISTORIC, PREHISTORIC, AND PALEONTOLOGICAL RESOURCES

Historic, prehistoric, and paleontological resources have been inventoried and evaluated on 75 sites on or within a 1-mile perimeter of the lease tracts. The investigations were conducted under present federal and state antiquities laws using current professional standards. Dr. David B. Madsen of the Utah Historical Society conducted the cultural resource investigation, and Dr. Wade E. Miller of Brigham Young University investigated the paleontological resources.

2.6.1 HISTORIC RESOURCES

2.6.1.1 Historic Periods

Historic cultural activities in the area can be subdivided into four periods: native American, early European exploration and trade, agrarian settlement, and mineral development.

Native American Culture. The Uinta Basin was primarily the homeland of the Ute Indians, who were divided into several closely knit bands. These nomadic groups subsisted by hunting and gathering and ranged throughout the Uinta Basin and into Western Colorado. The various Ute bands were in almost constant contact in their travel and frequently congregated for celebrations. The arrival of the first Europeans in the area marked the beginning of a series of drastic changes in the Indians' traditional way of life.

Early European Exploration and Trade. The source of the first European contacts was from the south, as Spanish explorers and traders attempted to extend their sphere of influence from Mexico. Reports of trade between Spaniards and Utes date back as early as 1712, and this trade steadily increased, despite the passage of laws in 1775 forbidding trade with Utes. The first recorded visit to the area was made by the Escalante expedition

in 1776, which intensified the pressure for trading with the Indians. It was not until the 1820s, however, that the use of the Uinta Basin intensified. This increased use was caused by an influx of French and American fur trappers and traders from the east and south. The first year-round white settlement, Fort Rubidoux, was established as a trading post in 1838 and soon became the central meeting point for travelers, traders, and trappers.

The declining demand for furs and the disruption of the Mexican War brought the trading era to an end by the late 1840s.

Agrarian Settlement. The colonization of the area by Mormon settlers in the latter decades of the 19th century strongly shaped the present economy and culture of the Uinta Basin. The first Mormons did not enter and explore the Uinta Basin until 1861, although the Wasatch Front was settled earlier.

It soon became apparent that the agrarian settlers and the Ute inhabitants were in direct competition throughout the state for the limited resources available. Following the Walker War in 1854, the Uintah Reservation was established in the Uinta Basin at the request of the settlers. The Utes refused to move to the reservation, leading to the renewal of hostilities from 1864 to 1869 (the Black Hawk War). Following their defeat, the Indians were finally removed to the reservation.

The 1870s were marked by the establishment of an Ashley Valley settlement, which later became Vernal. Several communities evolved in the surrounding area — Naples, Maeser, Jensen, Hallsville — and in 1886 a stake of the Church of Jesus Christ of Latter Day Saints was founded in Vernal.

During this settlement period, Uncompaghre Ute uprisings in western Colorado led to their transfer to the Uintah Reservation and the creation in 1881 of the Uncompaghre Reservation. Fort Thornburgh was established to protect the area but was abandoned three years later. Fort Duchesne, founded in 1886, was more successful and became a permanent settlement.

Mineral Development. The second most important human influence on the evolution of the Uinta Basin was the discovery and development of the area's rich mineral resources. The discovery of Gilsonite in the late 1800s led to the removal of a portion of the Uintah Reservation and mounting pressure for opening of the Indian land to white development. Finally, in 1895, the process of allotting 160-acre homesteads to the Indians began, so that the remainder of the reservation could be opened for mineral development. At the same time, the two reservations were combined into what is now known as the Uintah and Ouray Reservation. The reservation was officially opened for settlement by President Roosevelt in 1905.

The rapid development of Gilsonite mining in the basin and the opening of several small mines in Colorado led to the organization of the Uintah Railway to transport the ore over the Book Cliff Mountains to Mack, Colorado, where the line would connect with the Denver & Rio Grande Western Railroad. Following completion of the railroad in 1904, a toll road was built from the northern terminus of the railroad at Watson to Vernal, with a series of stage stops in between. Two of these stations were located just north of Tracts Ua and Ub at Ignacio and Bonanza.

The opening of the reservation lands precipitated a new wave of settlement. New towns and small farming communities sprang up, and a second stake of the Mormon Church was established at Fort Duchesne in 1910. Duchesne County was created in 1915. In 1933, additional land was withdrawn from the Uintah Reservation under the Taylor Grazing Act. In 1950, \$17 million was awarded to the Uintah and Uncompahgre Tribes as compensation for their losses. An additional \$7 million was received in 1960. These funds have since been used to support tribal development programs.

Although Gilsonite activities had declined in the Uinta Basin by the 1930s (with the exception of the American Gilsonite mine at Bonanza), energy-related development has continued to be important to the economic development of the area. Oil and gas exploration and production have been a major

activity since the 1950s. Recently, interest has turned to extraction of oil from tar sands and oil shale, more specifically on Tracts Ua and Ub south of Bonanza. Full-scale commercial development of these resources could signify the beginning of another major period of development in the Uinta Basin.

2.6.1.2 Historic Components

Use of the area around the oil shale Tracts Ua and Ub by the Ute Indians was limited. Although Indians are known to have traversed the White River, no trails were found in the study area. No evidence of other Ute cultural sites was revealed by archival research or the resource inventory.

The Ignacio Stage Station was the only major historic site on or near the study area identified in the investigations. A series of stage stops was constructed along the Uintah Railway toll road. The Ignacio Station, built in 1905, was the first stop north of the railroad terminus at Watson. The stage route followed Evacuation Creek while the station and bridge across the White River were being built. Many of the buildings at the Ignacio Station still remain, but they are in poor condition.

Other sites located during the investigation include a number of small cabins built by homesteaders in the early 1920s. These cabins are in poor condition or beyond repair.

2.6.1.3 Historic Significance

The most important historic feature on or near Tracts Ua and Ub is the Ignacio Stage Station. This site has been nominated for inclusion in the National Register of Historic Places by the Utah Historical Society. Although the remaining structures at the site are in poor condition, they are a good example of the type of architecture used in this part of the late frontier.

2.6.1 PREHISTORIC RESOURCES

The investigations have identified both expected and unexpected prehistoric resources in the study area. The resources consist of open sites and rock shelters that contain various types of artifacts and cultural remains of three to possibly five prehistoric cultures. Most of the sites are located along the White River. The located resources also support previous interpretations of Uinta Basin prehistory as well as suggesting new ones.

2.6.2.1 Prehistoric Occupants

The prehistoric resources indicate intermittent occupation of the study area from approximately 2225 B.C. to 1125 A.D. by hunter-gatherers and incipient agriculturalists similar to those of the prehistoric Great Basin and Colorado Plateau cultures. These resources also indicate influence from, or occupation by, Plains hunter-gatherers and agriculturalists. Paleo-Indian "big-game" hunters and Numic cultural traditions of the Shoshonian linguistic family, circa 1300 A.D. to recent times, are not represented in the artifact collection. Evidence for the presence of Fremont agriculturalists is inconclusive at this time. Earlier cultures may have been present in the study area, however, as many of the sites indicate subsurface cultural deposits.

2.6.2.2 Prehistoric Components

The prehistoric sites have been classified by the investigators as either open sites or rock shelters. Because of poor surface conditions, no functional uses of the sites, such as habitation or tool manufacturing, were discernible. Of the 32 sites inventoried, 25 were within one-half mile of the White River. Seven sites were on the tracts and 25 were in areas immediately adjacent to the tracts. The characteristics of the sites are summarized in Table 2.6-1.

Table 2.6-1

PREHISTORIC RESOURCE INVENTORY

Site	Condition	Description	Land Ownership
On-tract Sites			
42 Un 372	Undisturbed	Open site: surface scatter of lithic chipping debris - 100 m diameter	BLM ^(a)
42 Un 373	Possible surface collections made previously	Open site: chipped stone and fire-cracked river cobbles - 100 x 100 ft	BLM
42 Un 324	Undisturbed	Rock shelter: lithic chips, bone, charcoal - 130 x 12 ft	BLM
42 Un 408	Some potholes	Open site: single flake ca. 10-15 m length	BLM
42 Un 409	Probable surface collections made previously; some erosion	Rock shelter: 2 fire stains, possible depth of deposit - 5 x 5 m	BLM
42 Un 407	Potholes	Rock shelter: charcoal and chipping debris exposed by potholes, 150 x 10 ft	BLM
42 Un 406	Eroded	Open site: bifaces, hammerstone, historic debitage - 100 m	BLM
Off-tract Sites			
42 Un 118	Extensively vandalized but some undisturbed deposits remaining	Rock shelter: charcoal lenses and burned soil, corn cobs, chipping debris, charred animal bones, possible 2 m depth - 50 x 15 m	State
42 Un 355	Undisturbed	Rockshelter: surface scatter of fine chips, one notched point - 8 x 60 ft	BLM
42 Un 356	Eroded	Open site: surface scatter of chipping debris - 25 m diameter	State

Table 2.6-1 (Continued)

Site	Condition	Description	Land Ownership
42 Un 357	Eroded	Open site: chipping debris and single projectile point - 5 m diameter	State
42 Un 358	Eroded	Open site: single projectile point	State
42 Un 365	No apparent pot-holes; shelter has been littered with historic debris	Rock shelter: masonry granary, one projectile point, burned bone, charcoal	State
42 Un 366	Extensively pot-holed	Rock shelter: pictographs, flakes, and chipping debris	State
42 Un 367	Potholed; one 3 ft strip of deposit remains undisturbed; 10 ft long	Rock shelter: flakes and chipping debris	State
42 Un 368	Undisturbed	Open site: chipping debris, one blade - 200 ft x 100 ft	BLM
42 Un 369	Picked over but no potholes	Open site: chipping debris, fire-cracked cobbles - 300 x 200 ft	BLM
42 Un 370	Undisturbed	Open site: chipping debris, fire-cracked cobbles - 300 x 100 ft	BLM
42 Un 371	Undisturbed	Open site: fire-blackened cobbles, etched slate petroglyph	BLM
42 Un 374	Surface picked over; no pot-holes	Open site: chipped stone, fire-cracked and blackened cobbles - 100 x 100 ft	BLM
42 Un 375	No obvious pot-holes	Open site: debris and fire-cracker cobbles - 100 x 150 ft	
42 Un 376	Undisturbed	Open site: chipping debris, projectile points - 20 x 20 ft	Private

Table 2.6-1 (Continued)

Site	Condition	Description	Land Ownership
42 Un 377 (Thompson Site)	Almost totally vandalized	Open site: considerable depth with charcoal, chipping debris, and fire-blackened cobbles	BLM
42 Un 378	No potholes but probably picked over	Open site: lithic debris - 200 x 200 ft	BLM
42 Un 379	Eroded	Open site: chipping debris and core fragments	BLM
42 Un 380	Eroded	Open site: one projectile point	BLM
42 Un 381	Potholed	Rock shelter: chipping debris	BLM
42 Un 401	Some potting but mostly undisturbed	Open site: lithic debris, pottery, gray stone	State
42 Un 402	Some potholes but good general condition	Rock shelter: flakes, scrapes, bifaces, and choppers	
42 Un 403	Good	Pictograph	BLM
42 Un 404	Eroded	Rock shelter: possible projectile point or knife	BLM
42 Un 405	Probable surface collections	Open site: chipping debris sandstone slab wall, three shallow pits - 100 x 200 m	BLM

(a) Bureau of Land Management.

2.6.2.3 Significance of Prehistoric Resources

The significance of the prehistoric resources was not firmly established during the baseline survey. The disturbed surface conditions of the site locations and the poor understanding of Uinta Basin prehistory will preclude final evaluation without subsurface test excavations of the more promising sites. For a further discussion of this program, refer to Section 4.8.

2.6.3 PALEONTOLOGICAL RESOURCES

Most sections in the study area were found to contain at least some fossils. Identified fossils include leaf imprints and impressions, petrified wood, insects in larval and adult forms, fish scales and bones, turtle shells, crocodile teeth and bones, and mammalian teeth and bones. These fossil resources represent a valuable record of paleo-environments of the Eocene Epoch in the Uinta Basin.

2.6.3.1 Paleontological Periods

The exposed strata consists of alluvial (stream-related) and lacustrine (lake) deposits. A study of the floral and faunal assemblages in these strata reveals that these assemblages inhabited a region whose climate was warm and humid.

The primary formations involved are, in ascending order, the Green River and Uinta formations. These formations have yielded an abundance of fossils in many areas within the Uinta Basin.

The Uinta Formation, composed of sandstones, represents the youngest strata. It is rich in hydrocarbons, the remains of the mostly microscopic life that existed in the Eocene lakes, and, in addition, it contains a great number of megascopic fossils, which attest to the richness of life forms that lived in and adjacent to the ancient Green River lakes.

The Green River Formation has special scientific importance because its fine-grained sediments and quiet-water deposition have allowed fine details of fossils, usually lost, to be preserved. Veination in leaves, insect wings, and even insect tracks can be clearly seen.

2.6.3.2 Paleontological Components

Fossils occurring in the study area are listed in Table 2.6-2. Leaf material, some petrified wood, insects, and fish were found in the Green River Formation; and additional petrified wood, turtle, crocodile, and mammalian specimens were found in the Uinta Formation. With the exception of algae, plant fossils consist of angiosperms (flowering plants). Fossil insects consist mostly of flies, the bulk of which are in larval form. All identified fish remains are of a freshwater gar pike. The identified mammal specimens belong to several types of brontothere (an extinct relative of the rhinoceros).

A wide variety of insect fossils have been identified in and adjacent to Tracts Ua and Ub. Fish remains were surprisingly scarce. Only scales and occasional fragmental bones were found. Although more than one type of fish is represented, only the gar pike could be identified. Collected turtle specimens have not yet been sufficiently prepared for identification, although probably more than one genus is represented in the area.

Several crocodilian teeth evidently belong to the genus *Allognathosuchus*. Although some unidentified bone fragments may belong to a uintathere (a large mammal of the order *Dinocerata*), the only identified type of mammal is a brontothere (titanotheres), or thunder beast.

2.6.3.3 Paleontological Significance

These fossils are considered scientifically important: they yield valuable information on early climatological conditions, early environments, and evolutionary processes. In some instances, it may be possible to determine

Table 2.6-2

PALEONTOLOGICAL RESOURCE INVENTORY

Site	Fossil Types	Geological Formations	Significant
On-tract Sites			
1	Unidentifiable plant debris	Uinta	No
2	Unidentifiable plant debris	Uinta	No
3	Fragmental plant remains	Green River	No
4	Unidentifiable plant debris	Lower Uinta, Upper Green River	Yes
5	Fragmental plants, some complete leaves	Green River	
6	Unidentifiable plant debris	Lower Uinta, Upper Green River	No
8	Fragmental plants, some complete leaves	Green River	Yes
9	Fish scales, leaves	Green River	Yes
20	Turtle shell and bone, plant fragments	Uinta	Yes
23	Turtle shell fragments, wood	Uinta	No
24	Brontothere teeth, turtle shell	Uinta	Yes
28	Brontothere bone, petrified wood	Uinta	Yes
29	Petrified wood	Uinta	No
30	Turtle shell fragments	Uinta	No
32	Unidentifiable bone fragments	Uinta	No
34	Fish scales	Green River	No
35	Wood fragments	Uinta	No
36	Wood fragments	Uinta	No
Off-tract Sites			
7	Insects, leaves	Green River	Yes
10	Unidentifiable wood fragments	Uinta	No
11	Insects	Green River	Yes

Table 2.b-2 (Continued)

Site	Fossil Types	Geological Formations	Significant
12	Insects	Green River	Yes
13	Wood fragments	Uinta	No
14	Insects, plant fragments, some leaves	Green River	Yes
15 a,b,c	Insects, plant fragments	Green River	No (a,b) Yes (c)
16	Insects, plant fragments, seeds	Green River	Yes
17	Insects	Green River	Yes
18	Plant fragments, some complete leaves	Uinta	Yes
19	Plant fragments, some complete leaves	Lower Uinta, Upper Green River	Yes
21	Some petrified wood	Uinta	No
22	Brontothere bones, turtle shell	Uinta	Yes
25	Petrified wood	Uinta	No
26	Brontothere teeth, turtle shell fragments	Uinta	Yes
27	Petrified wood	Uinta	No
31	Brontothere teeth and bones	Uinta	Yes
33	Petrified wood	Uinta	No
37	Fragmental plants, some complete leaves	Uinta	No
38	Fragmental plants, some complete leaves	Uinta	No
39	Brontothere teeth and bones, alligator teeth, turtle shell	Uinta	Yes

the place of origin for types of plants and animals. The most significant fossils found during the survey were those of insects and brontotheres. The plant fossils are important because such an abundance of well-preserved specimens is relatively rare in the fossil record; the animal fossils are important because of their usefulness in dating and in evolutionary studies.

The most significant paleontological sites are located off tract, north of the White River. The ontract resources are, for the most part, petrified wood and plant fossils. Only a sampling of the most important ontract specimens will be required prior to any construction activities, as described in Section 4.8.

2.7 AESTHETICS

Aesthetic features for a land mass are considered to be the physical and cultural elements of landscape for an area perceived by humans through the senses. These elements of landscape are moderated by human feelings through emotional, cognitive, and evaluative judgments. The primary guide for any judgment of aesthetics is beauty. In brief, beauty is that aggregate of qualities in a person or thing that promotes harmony. For the purpose of this study, aesthetic features are defined narrowly in terms of landscape units. A landscape unit is an area of land possessing similar, yet distinguishing visual characteristics of landform, rock formations, water surfaces, and vegetative patterns.

2.7.1 THE REGIONAL AESTHETIC SETTING

The boundary landforms around the Uinta Basin are the primary aesthetic features of the region. The most accessible of these are the Uinta Mountains, Book Cliffs, Wasatch Plateau, Flaming Gorge National Recreation Area, Dinosaur National Monument, and Green River. The area is known as red rock country, indicating the dominantly perceived color. Distant views are common, and sounds are nonirritating because of few urban-industrial influences. Dust, daily extremes in temperature, and dryness influence the perception of the natural features of the area.

Tracts Ua and Ub and a 1-mile border area were divided into three mappable units that are identified as the ridgetop-basin landscape unit, the canyon landscape unit, and the White River landscape unit.

2.7.2 THE RIDGETOP-BASIN LANDSCAPE UNIT

The ridgetop-basin unit includes areas with panoramic views of the surrounding landscape. The distinct contrast between the brown-to-buff-colored Uinta Formation and the different strata of the underlying Green River Formation is apparent from this unit. The views are so distant that the aesthetic experience is primarily visual. In contrast to the

panoramic views, the ridgetop setting is dominated by unusual micro-landforms, such as lichens, ancient ripple marks, precipitation cusps in rock, honeycombed appearance of some calcareous rock, and seedling pinyon trees. Mammals, birds, and small reptiles are frequently seen. Numerous rock pinnacles, waterpockets, balanced rocks, and rock windows are prominent geologic features of the unit. Shallow rock depressions on the mesa tops add variety to the appearance of the ridgetop-basin landscape unit.

2.7.3 THE CANYON LANDSCAPE UNIT

The canyon landscape unit includes Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. Because the water-land interface is such a dominant element in White River Canyon, this area will be considered separately. The canyon landscape unit is characterized by enclosed views enhanced by geologic detail, microchanges in vegetation, and water in ephemeral stream courses. Evacuation Creek Canyon has many unusual cavities along the rock walls below the protruding ledges that give a coarse, honeycombed appearance to the canyon. The nearly vertical walls direct attention toward the canyon and along the sharp boundary between the walls and the usually clear Utah sky. A distinctive white bed of volcanic ash is visible along the walls of Evacuation Creek. Small pools are formed when relatively clear groundwater seeps through the sand or along the edge of the creek bed.

Desert varnish, composed of the reds, blues, and blacks of oxides of iron and manganese, gives the canyon walls and overhanging ledges a variegated appearance. Mudflows have also added to the streaked appearance on the walls.

Evacuation Creek differs from other canyon landscape units in its more confined views, more frequent streamflow, and greater diversity of vegetation types, including the more colorful riparian associations.

Southam Canyon has fewer enclosed views, while Asphalt Wash has fewer meanders and lies in a more symmetrical valley than does Evacuation Creek. Deviations made by humans include dirt roads along Southam Canyon and Asphalt Wash, and an occasional deserted corral.

2.7.4 THE WHITE RIVER LANDSCAPE UNIT

Since the White River is the most prominent feature and the only perennial stream on the project area, it is considered as a separate landscape unit. The views are characteristically enclosed within the limits of White River Canyon; however, considerable detail and movement may be observed from the river itself. The canyon walls are usually steep and are composed in places of stream-cut facets with large vertical relief and vertical joint and fracture lines superimposed on the horizontal stratifications. The land-water interface along the river is a continuation of point bars protruding from the canyon walls and cutbanks on the opposite side of the river. Thinly laminated silt beds on the bars, and alluvial deposits of various sizes exposed on the cut banks reveal a cross section of the river's history. Rock ledges, windows, rock alcoves, and recent rockfalls are common. The highest ridge visible from the river is in sharp and jagged contrast with the sky.

Channel bars, snags, and driftwood are common in the river. Beaver dams and their occupants are sometimes seen. Lower point bars show evidence of meander scars that emphasize the sinusoidal nature of the channel pattern. Many of the more stable point bars are thickly vegetated with green cottonwoods. Cattle frequently occupy these riparian areas, and deer are occasionally observed, particularly east of Ignacio Bridge.

Many small insects, grasshoppers, and garter snakes appear frequently along the stream banks. Ducks, various shorebirds, and raptors also add variety to the aesthetic setting. The river is extremely turbid,

get reflected sunlight seen from the bridge, or from the riffles during sunrise give a pleasing contrast. At sunset, long shadows on the river emphasize ridgeform and vegetation shapes.

There are two seasonal changes in the White River that greatly alter the landscape appearance. In the winter, the river freezes and forms a white band of ice that winds through the canyon. In the fall, some riparian vegetation turns various shades of red, orange, and yellow, and contrasts with evergreen shrubs and trees.

REFERENCES — SECTION 2

- 2-1 Final Environmental Baseline Report, White River Shale Project,
VTN, Denver, Colorado, 1977.
- 2-2 Partial Exploration Plan, Environmental Baseline Data Collection
and Monitoring Element, Sun Oil Company, Phillips Petroleum Com-
pany, and White River Shale Oil Corporation, July 1974.
- 2-3 R. E. McDonald, "Eocene and Paleocene Rocks of the Southern and
Central Basins," Geologic Atlas of the Rocky Mountain Region,
Rocky Mountain Association of Geologists, Denver, 1972.
- 2-4 W. H. Bradley, "Origin and Microfossils of the Oil Shale of the
Green River Formation of Colorado and Utah," U.S. Department of
Interior, Geological Survey, Professional Paper 168, Washington,
D.C., 1931.
- 2-5 W. B. Cashion and J. R. Donnel, "Revision of the Nomenclature of
the Upper Part of the Green River Formation, Piceance Creek
Basin, Colorado, and Eastern Uinta Basin, Utah," U.S. Department
of Interior, Geological Survey, Bulletin 1394-3, Washington,
D.C., 1974.
- 2-6 W. B. Cashion, "Geology and Fuel Resources of the Green River
Formation, Southern Uinta Basin, Utah and Colorado," U.S. Depart-
ment of Interior, Geological Survey, Professional Paper 548,
Washington, D.C., 1967.
- 2-7 WRSP Geologic Exploration Program Report, Cleveland-Cliffs Iron
Co., June 30, 1974.
- 2-8 J. C. Coffman and Von Hake, "Earthquake History of the United
States," U.S. Department of Interior, National Oceanic & Atmos-
pheric Administration, Publication 41-1, Washington, D.C., 1973.
- 2-9 W. H. Bradley, Green River Oil Shale - Concept of Origin Extended,
Geological Society of America, New York, 1970, pp. 985-1000.
- 2-10 Uinta Basin Association of Governments, et al., "Uinta Basin Area-
wide Water Quality Management Plan," Roosevelt, Utah, 1977.
- 2-11 L. H. Austin and G. V. Skogerboe, "Hydrologic Inventory of the
Utah Study Unit," Utah State Division of Water Resources,
PRWG 40-5, Utah Water Research Laboratory, Salt Lake City, 1970.

- 2-12 W. B. Cashion and J. H. Brown, "Geology of the Bonanza-Dragon Oil-Shale Area, Uintah County, Utah, and Rio Blanco County, Colorado," U.S. Department of Interior, Geological Survey, OM. 153, Oil and Gas Investigations Map, Washington, D.C., 1956.
- 2-13 G. C. Slawson, Jr., Groundwater Quality Monitoring of Western Oil Shale Development: Identification and Priority Ranking of Potential Sources, EPA-600/7-79-023, U.S. Environmental Protection Agency, Environmental Monitoring and Support Lab, Las Vegas, Nevada, 1979.
- 2-14 R. D. Feltis, "Water from Bedrock in the Colorado Plateau of Utah," U.S. Department of Interior, Geological Survey, and the Utah Oil and Gas Conservation Commission, Utah State Engineer Tech. Publication No. 15, Salt Lake City, 1966.
- 2-15 D. Price and L. L. Miller, "Hydrologic Reconnaissance of the Southern Uinta Basin, Utah and Colorado," U.S. Department of the Interior Open File, No. 74-352, Washington, D.C., 1974.
- 2-16 H. B. Singh et al., "Impact of Stratospheric Ozone on Tropospheric Air Quality," Proceedings, Ozone/Oxidants Interactions with the Total Environment II, APCA Specialty Conference, Houston, Texas, 1979.
- 2-17 H. D. Harrington, Manual of the Plants of Colorado, Swallow Press, Chicago, 1964, p. 666.
- 2-18 A. H. Holmgren and J. L. Reveal, Checklist of the Vascular Plants of the Intermountain Region, Forest Service Research Paper, INT-32, Washington, D.C., 1966.
- 2-19 D. F. Day, Utah Investigation and Management Recommendations Book, Utah Division of Wildlife Resources, 1979.
- 2-20 M. L. Ranck, Mammals of the East Tavaputs Plateau, M. S. Thesis, University of Utah, Salt Lake City, 1961.
- 2-21 M. L. Perry, "Nongame Mammal Inventory of Utah Oil Shale Area" from Studies for Wildlife on Energy Areas, Utah Division of Wildlife Resources and the U.S. Bureau of Land Management, 1975, pp. 1-50.
- 2-22 D. F. Balph, et al., Desert Biome, Reports of 1973 Progress, Curlew Valley Section RM 74-1, Utah State University, Logan, 1974.
- 2-23 J. Torres, et al., Essential Habitat for Threatened or Endangered Wildlife in Colorado, Colorado Division of Wildlife Resources, 1978.

- 2-24 R. H. MacArthur and E. O. Wilson, The Theory of Island Biogeography, Princeton University Press, Princeton, N.J., 1967.
- 2-25 F. H. Borman and G. E. Likens, Pattern and Process in a Forested Ecosystem, Springer-Verlag New York Inc., New York, 1979.
- 2-26 J. H. Wlosinski, Predictability of Stream Ecosystem Model of Various Levels of Resolution, Ph.D. Thesis, Wildlife Ecology, Utah State University, Salt Lake City, 1979.

Section 3

DESCRIPTION OF THE PROPOSED ACTION

3.1 INTRODUCTION

Section 3 summarizes the most probable action proposed for the White River Shale Project. The description of the project's mode of development and facilities does not include a discussion of the alternatives, an evaluation of environmental impacts, or the procedures that White River is proposing to mitigate these impacts. These elements of the White River Shale Project are discussed in Section 7, "Alternatives and Selection Rationale," Section 4, "Planned Environmental Protection Procedures," and Section 5, "Environmental Effects of the Proposed Action After Mitigation."

For the purpose of this report, the "indirect heat vertical retort" used in Phase I descriptions is the Union B retort, and the "direct heat vertical retort" is the Paraho DH retort. For modeling of air quality impacts in all three phases, the "indirect heat retort" is the Union B retort, the "direct heat retort" is the Paraho retort, and the "fines-type retort" is the Tosco II retort. Final choices of retorts will depend on evolving technology and/or the results of retort operation during Phase I of this project.

3.2 OBJECTIVES

3.2.1 NEW ENERGY SOURCES

The White River Shale Project is designed to implement the federal oil shale prototype program for stimulating private industry to produce commercial quantities of oil from shale. This step toward national energy independence can be taken once the technical and economic risks are reduced to a level that can attract investment capital.

The White River Shale Project conforms with Section 102(b)(3) of the Powerplant and Industrial Fuel Use Act of 1978. This section states that one purpose of the act is "to encourage and foster the greater use of coal and other alternate fuels, in lieu of natural gas and petroleum, as a primary energy source."

3.2.2 RESOURCE RECOVERY

In planning the proposed action, a prime requirement was that the resources be recovered in a way that represents the best return to all interested parties.

3.2.3 ENVIRONMENTAL PROTECTION

The White River Shale Project will be developed in a manner to ensure that the environmental integrity of the area is maintained.

3.3 SUMMARY AND SCHEDULE OF PROJECT DEVELOPMENT

3.3.1 INTRODUCTION

This section summarizes the most probable plan for mine development and for construction and operation of aboveground shale oil production facilities. The summary is limited to the physical actions to be taken and the physical facilities that will result. Environmental protection procedures and environmental impacts are discussed in Sections 4 and 5. Alternatives are discussed in Section 7.

3.3.2 OVERALL DEVELOPMENT SCHEDULE

The overall development schedule is presented in Figure 3.3-1. As shown, development will begin with the sinking of three vertical mine shafts and the development of sufficient horizontal mine openings to furnish up to 26,700 tons per stream day (TPSD) of raw shale. At the same time, one direct-heat and one indirect-heat vertical-type retort will be constructed. The Phase I modular program will run alone for approximately 5 years. During the latter part of this period, the two retorts will be operated under various conditions for testing purposes, and to produce up to 14,930 barrels per stream day (BPSD) of raw shale oil.

Work on two mine shafts will start in the second half of the first project year. The two shafts will be bottomed, a third shaft required for ventilation completed, and development mining in the ore zone will be under way in about 2-1/2 years. Approximately 1-1/2 years of preproduction development mining will be required to bring the mine to a full Phase I capability of 26,700 TPSD.

Phase I will be integrated into Phases II and III (the commercial operation phases), which will nominally produce 50,000 BPSD and 100,000 BPSD of raw shale oil, respectively. Phase II engineering will start at the beginning of 1986 and continue through the second quarter of 1988. Additional mine

development will start at the end of 1985. Phase I facilities will continue to operate during this period. Phase II operation (first-train startup and mine production for support of the first train) will be initiated about the middle of 1988, with full production of approximately 50,000 BPSD at the beginning of 1990. Phase III operation (second-train startup and supporting mine production for the second train) will be initiated at the beginning of 1991, with full production of approximately 100,000 BPSD at the beginning of 1993. Both trains will continue full production to depletion of oil shale reserves, at which time the entire facility will be decommissioned and abandoned. Decommissioning and abandonment plans are discussed in Section 3.21.

The current schedule is based on present knowledge of oil shale mining and processing. Knowledge gained later, especially during Phase I, together with regulatory and economic changes that could occur during early project activities, may have a significant effect on the total schedule.

3.3.3 EXPLORATORY, BASELINE, AND PRELIMINARY STUDIES

In the overall White River Shale Project program, one of the early stages was exploratory work on Tracts Ua and Ub. This work consisted of core drilling and geologic examination to establish the principal characteristics of the oil shale mining zone and the material lying above it. In a companion program carried on in various engineering offices, a series of preliminary conceptual engineering designs and plans of operation for mining and processing were developed. The results of these field investigations and engineering designs are summarized in Section 7, "Alternatives and Selection Rationale," and in this section.

In a parallel program, White River Shale Project developed baseline environmental data relevant to Tracts Ua and Ub. This information is presented in condensed form in Section 2, and is discussed more fully in the First Year Environmental Baseline Report (Ref. 3-1).

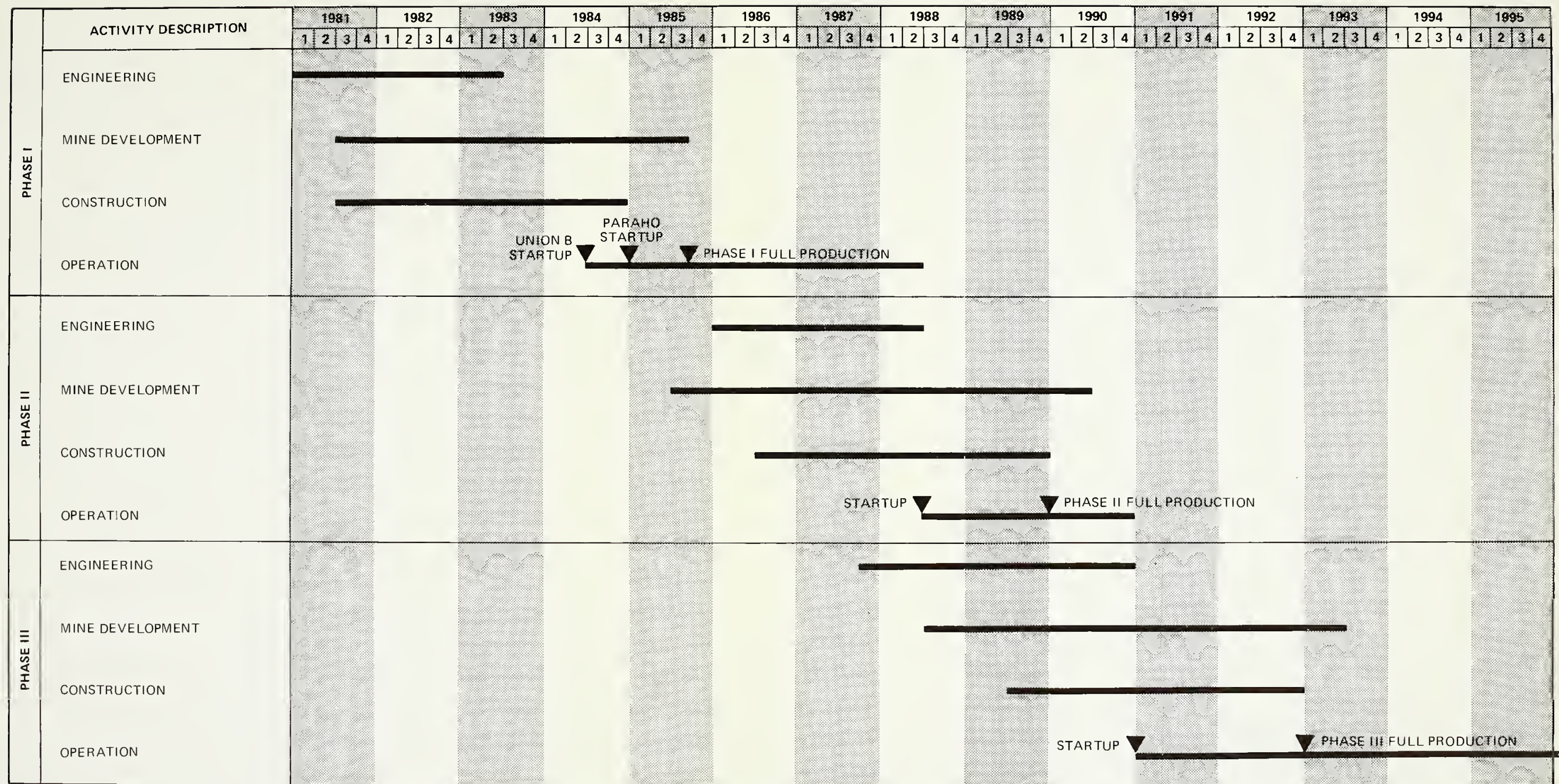


Figure 3.3-1 WHITE RIVER SHALE PROJECT SCHEDULE

3.3.4 LAYOUT OF FACILITIES

The specific location of Tracts Ua and Ub in northeast Utah requires that operations fit existing transportation and logistics patterns. A study of the area indicates that the nearest available railhead for receipt of material for this project is at Craig, Colorado. Establishing rail spurs that would come closer to the site is impractical at this time. Transportation from Craig will be by truck over existing highway systems, and it may be necessary to upgrade portions of this system. These questions are discussed at greater length in other portions of this Detailed Development Plan. An area map indicating the transportation routes is shown in Figure 3.3-2.

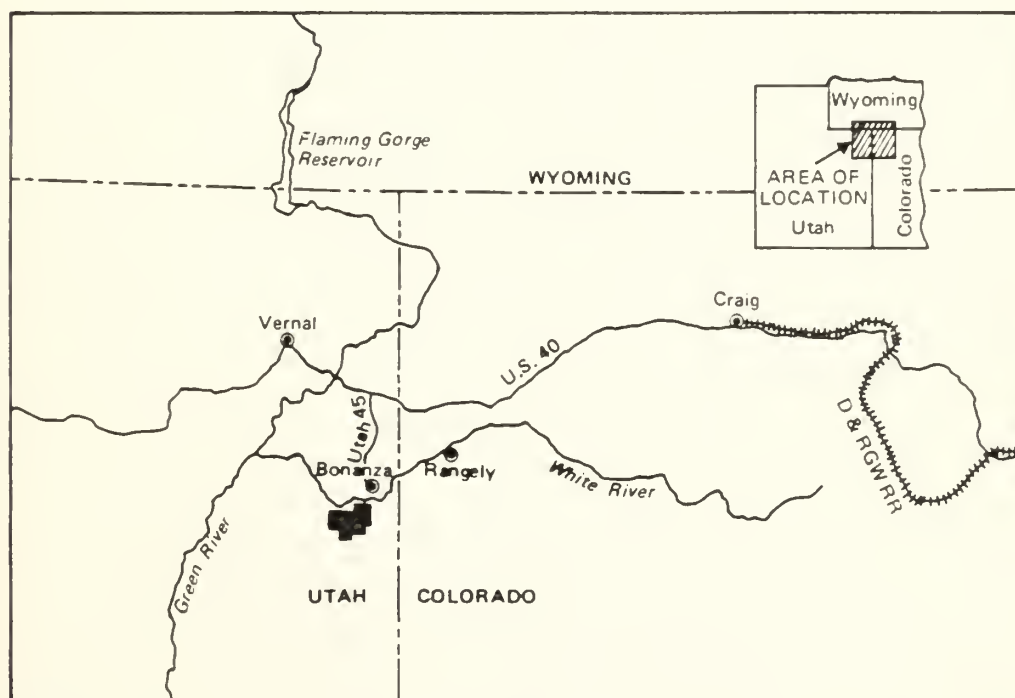


Figure 3.3-2 AREA MAP

Personnel required during the construction period of this project, both for mine development and facility construction, will be drawn from a relatively wide area because there is not an adequate labor supply nearby. Camp facilities will be necessary, since existing residential provisions in the area are not adequate to accommodate the level of manpower required. To minimize travel and lost time, the construction camp will be located in the vicinity of Bonanza, about 10 miles from the site.

The supply of water will be pumped from a reservoir to be built by the state of Utah on the White River. These facilities are within easy reach of the tracts, requiring a pipeline 1.7 miles in length.

Electric power for this project will be available from Moon Lake Electric Association, Inc., on an existing power grid that can be extended to the jobsite. As power requirements increase and exceed the capability of this grid, the Moon Lake system will go through expansions of delivery capability to meet project requirements.

The layout of facilities and land use on the tracts are reasonably confined by the nature of the project and the rugged terrain. The largest single dedication of tract terrain is the planned use of Southam Canyon for the disposal of the processed shale. It is felt that the overall environmental effect will be least if processed shale is disposed of in Southam Canyon.

The underground operations must remove shale of required quality from the area of the two tracts, subject to boundary provisions, pillar provisions, and the requirement for adequate block support under the process area built on the surface. The choice of mine portals and ventilation shafts has been related to the disposition of the ore underground in order to minimize the movement of materials underground, with attendant problems of dust, equipment requirements, and hauling costs.

The choice of location of the process facilities site on the surface is related to the underground operations and accessibility to Southam Canyon, again to minimize unnecessary movement of materials. In any event, a significant amount of blasting and leveling will be necessary because there is no large, level plot suitable for operations that is available on the tracts. The proposed plan minimizes the removal of surface material through a program of terracing the process area to conform as far as possible to natural elevations. The location of tankage and support buildings has been dictated by the availability of naturally available small areas suitable for these purposes. Efforts have been made to minimize the amount of site preparation, environmental effects, and costs while assuring a high level of safety and fire protection.

3.3.5 MINING

The mining of oil shale from Tracts Ua and Ub will require approximately 12 years for full development. The development of a mine property underground must proceed in an organized, orderly fashion, and there are limits to the rate at which mining areas can be opened up to sustain a continually increasing production level. Mine production will be developed in three stages, as described briefly below. (The mining program is fully described in Section 3.5.)

3.3.5.1 Phase I

The White River Shale Project program starts with the sinking of 28-foot-diameter service, production, and air exhaust shafts. Station, entry, and panel preproduction development mining will be accomplished in 50 months when Phase I full production of 26,700 TPSD will be achieved. A proven room-in-pillar mining method will be used as described in Section 3.5.

3.3.5.2 Phase II

After the Phase I mine has been fully developed, the mining operation will be expanded. The most probable plan calls for sinking a decline conveyor

tunnel to the east into the ore to provide for delivery of the added tonnage. Additional air intake and exhaust shafts will be sunk for this expansion.

In Phase II, there will be sufficient mine capacity to furnish raw shale to eight retorts. Up to 95,700 TPSD of shale will be mined. Phase II development of the White River program will require approximately 4 years to complete.

3.3.5.3 Phase III

In Phase III, a second decline to the west and three additional intake and three exhaust shafts will be sunk. There will be sufficient conveying and hoisting capacity to furnish raw shale to operate 15 retorts. The quantity of shale to be mined will be about 178,500 TPSD as Phase III reaches full operation.

3.3.6 FEED PREPARATION AND TRANSPORTATION

During all three phases, the process of readying the mined oil shale for retorting will require facilities for crushing, screening, and storing the raw shale, and for feeding it to the retorts. Two stages of crushing operations will take place before retorting. Preparation of the oil shale feed will begin with the primary crushing stations located underground at the mining level. Secondary crushing will take place on the surface, near the retorts. The type of retort used will determine the size to which the oil shale must be crushed. Covered conveyors will transport oil shale to crushers, the stockpile area, bins, and the retort feed hoppers.

Primary crushed oil shale will be stockpiled at a location between the primary crusher and secondary crushing plant to ensure uninterrupted operation of the secondary crusher and continuous feed to the retorts. The mine haulage system and primary crushing operations will be interdependent. If the primary crusher is shut down, haulage from the mine will be stopped, and the secondary crusher will then be fed from the stockpile.

3.3.7 RETORTING

In the three phases of the White River Shale Project, the retorts will have the following production capacities: Phase I, 14,930 BPSD of raw shale oil; Phase II, 58,740 BPSD; and Phase III, 109,770 BPSD.

The objectives of Phase I are to evaluate and assess retort technology and related mining, crushing, and material handling operations and their environmental impacts. During this phase, one direct-heat vertical type retort and one indirect-heat vertical type retort will be installed and operated.

Upon successful completion of Phase I, Phases II and III will begin. Additional vertical-type retorts and fines-type retorts will be installed to meet the equipment requirements for commercial plant operation. A first train will be built in Phase II and a second train will be added in Phase III to complete the final full-scale commercial plant. The first train, which will permit operations at 50 percent of capacity, will include the original retorts installed during Phase I. The final full-scale plant will contain about 15 retorts.

Fines produced during crushing and screening of the raw shale in Phase I will be stockpiled for recovery during Phases II and III. The quantity of fines produced will be confirmed in Phase I operation.

Commercial operation in Phases II and III will include provisions for utilizing fines. The use of three different types of retorts — DH, IH, and fines-type — has been based on specific process needs, coupled with the requirement for high operating and thermal efficiency. Since the vertical-type retorts (both DH and IH) may not be able to handle fines, fines-type retorts could be used so that the fines produced during raw shale crushing and screening can be processed rather than discarded.

3.3.8 GAS AND OIL PROCESSING

No upgrading of the crude shale oil product is planned for any of the three phases of development. The raw shale oil product will be dewatered and desalted before being shipped. Product gases will be treated to remove ammonia and hydrogen sulfide.

3.3.9 SOILS HANDLING

Construction of project facilities will cause little surface disturbance to Tracts Ua and Ub. Most excavated material from the plant site area will be suitable for use as some type of fill in the immediate area. Some excavated material may have to be crushed before being used as structural load-bearing fill. Any high-organic-content topsoils not suitable for fill will be stockpiled for later use in revegetation.

3.3.10 PROCESSED AND RAW SHALE DISPOSITION

The disposition of processed shale from the retorts represents one of the major problems to be dealt with in the White River Shale Project. There are currently no commercial operations of this kind, so the conceptual plans presented herein must be regarded as the best developed to date. The White River Shale Project is a phased program of orderly development that includes a relatively small-scale first phase, during which the techniques for disposing of large quantities of processed shale will be perfected.

The topographic configuration of Tracts Ua and Ub and environmental considerations related to surface drainage make Southam Canyon the preferred place for disposition of processed shale. This Detailed Development Plan describes a staged program that will permit revegetation at an early date following startup of the plant.

3.3.11 SOLID WASTE DISPOSAL

In the course of developing and operating the White River Shale Project facilities, relatively small amounts of solid waste (i.e., small compared

with the amounts of processed shale) will be generated. Non-hazardous wastes will be disposed of in a landfill operation concurrent or phased with processed shale disposal. Hazardous wastes will be handled in accordance with the requirements of the Resource Conservation and Recovery Act.

3.3.12 SUPPORT FACILITIES AND REQUIREMENTS

When the White River Shale Project facilities are fully established on Tracts Ua and Ub, the operation will be essentially self-supporting except for the water requirement, which is estimated at 27,100 acre-feet per year, (see Section 7.14) and the requirement for minor amounts of chemicals, diesel fuel, and supplemental fuel. The project will normally be exporting electric power (except during Phase I when electric power will be imported) and will be self-sufficient in other utilities.

3.3.13 ANCILLARY FACILITIES AND MAINTENANCE

Since this project is being constructed in a relatively remote location, there must be on-tract facilities for repair and maintenance of a wide variety of equipment, for full care of personnel, and for storage and shipment of materials from the plant.

3.3.14 WATER SUPPLY AND FACILITIES

The supply of water required by the White River Shale Project in its various stages will come from the nearby White River. The quantities needed will be purchased from a supply available behind a dam. This dam is proposed by the State of Utah to meet multiple-use needs in the area, including those of the White River Shale Project.

3.3.15 WASTEWATER MANAGEMENT PLAN

White River Shale Project has recognized the very significant value of water in this area and has incorporated techniques for minimum water use as well

as wastewater treatment and reuse. There are no plans for allowing wastewater to be discharged from this operation to the White River or any receiving stream.

3.3.16 CORRIDOR PLANNING

At this time, the planning of corridors off tract is in a conceptual stage. The precise source of power lines and water pipelines to serve this area has not been determined. Appropriate governmental agencies have been contacted to establish probable corridors to be used as the project proceeds. The ultimate destination of the raw shale oil will be an existing refinery in Borger, Texas.

3.3.17 PRODUCT TRANSPORT

In Phases II and III, the shale oil will move by pipeline to refiners for further processing. The most probable plan shows this material moving generally southeast toward Borger, Texas, where it will be processed in an existing refinery. Generally, it follows established pipeline paths through that territory.

During Phase I, the oil product will move by truck, since the small quantity involved makes other modes of transport impractical.

3.3.18 BY-PRODUCT PLAN

Sulfur is the only by-product expected to be generated by the project. This sulfur will be stored as a solid during Phase I, and exported to available markets by truck during Phases II and III. Ammonia generated by gas treating will be incinerated at the site.

3.3.19 CONSTRUCTION PLAN

The plan for construction of an oil shale mining and processing facility on Tracts Ua and Ub includes all field operations necessary for establishing access and moving workers, equipment, and materials into the area;

provision of housing and other amenities for workers at the Bonanza area campsite; and the major construction operation at the mining site. Construction operations at the mining site include excavation and preparation of the site for plant construction and the installation of all buildings, equipment, and support structures necessary for implementation of the commercial production plants.

All three phases of the development program will involve operations at the mining site. These operations have been carefully planned and phased to allow orderly development of the mining facility, minimize construction costs and necessary excavations, and avoid adverse environmental effects resulting from construction activities.

During Phase I, the two-retort facility will be built, and the mine will be developed by sinking three 28-foot diameter shafts. This will require a work force of about 1,100 men and transport of 50,000 tons of materials and equipment to the site. Oil shale removed during expansion of the underground portion of the mine, and suitable for retorting, will be stockpiled until the first of the two retorts becomes operational. Soil, rock, and low-grade shale will be disposed of on site. Improvement of roads leading to the site will be necessary before these construction activities can begin.

During Phases II and III, the commercial production plant will be built, and the mine will be brought to full-scale production by sinking and outfitting, on a phased basis, several more ventilation shafts and two declined shafts. Oil shale removed for expansion of the underground portion of the mine will be stockpiled until the plant is operational, since Phase I is scheduled to operate for 3 years. The mine will be developed in two phases to coincide with completion of production plant Trains 1 and 2.

Construction of Phases II and III constitutes the main construction effort of the White River Shale Project program, including the two process trains

and their support facilities. The construction effort consists of two overlapping phases of 2-1/2 years each, totaling 4 years, and it will include major earthmoving operations, foundation laying, and equipment installation. It will require a peak work force of about 3,200 manual and nonmanual workers and transport of 350,000 tons of materials and equipment to the construction site.

3.3.20 OPERATIONS MANPOWER

The patterns of development of operations manpower and the levels reached during all phases of the White River Shale Project are presented in conjunction with the discussion of construction manpower.

3.3.21 DECOMMISSIONING-ABANDONMENT PLAN

If the operation on Tracts Ua and Ub is suspended for a period of time, decommissioning provisions will be undertaken. Further, at the exhaustion of shale reserves or because of relinquishment of the lease, abandonment procedures will be instituted. Plans for both of these eventualities have been formulated. The object of these plans is to ensure that during decommissioning-abandonment the leases and the improvements are treated properly and that the environment is protected.

3.4 LAYOUT OF FACILITIES

3.4.1 GENERAL

The overall layout of WRSP facilities is dictated primarily by the distribution of oil shale in the Ua and Ub sectors and the complex limitations imposed by the rugged terrain.

The primary factors determining the facility layout are:

- Appropriate relative locations for the main plant and support facilities to maximize overall plant efficiency and minimize environmental impacts as affected by onsite transit of oil shale and products of the oil shale process plant
- Maximum reuse of facilities throughout all stages of project development
- Ease of access to the site and to the various onsite facilities and equipment
- Appropriate locations for water supplies, runoff collection, and shale disposal area, dictated largely by the terrain
- Minimization of deleterious effects on the terrain by excavation, construction, and potential floods
- Prevention of pollution due to products and wastes resulting from oil shale processing

The overall site plan and process area plot plan are presented in Figures 3.4-1 and 3.4-2 for all phases. As shown in Figure 3.4-1, the main process area is centrally located between the Ua and Ub oil shale centroids. Although potentially more favorable terrain locations are available for the process plant, these locations would require more extensive and less efficient facilities and equipment for transporting oil shale from remote sections of the mine and processed shale to Southam Canyon, all of which would contribute negatively to environmental problems.

3.4.2 SITE ACCESS

Because of the rugged terrain and inadequacy of current roads in the area, roads must be improved or built both for plant access and on-tract access to the various facilities. During Phase I, a road will be built from the existing road south to the main plant site. The main plant access roads will be provided, along with on-tract roads branching from the main road to the process plant, water supply pump station, wastewater and storm runoff holding basin, pumping station, secondary crushing area, and processed shale disposal area. The only additional access required in Phases II and III will branch from the Phase I access road to the entrance of the mine portal and vent shaft sites. A road will be required later for the Ub vent shaft sites.

The main access road will enter the plant on the east side, where most of the logistics support facilities will be located. This road will join existing Highway 45 at a point 0.8 mile south of the White River. From that point, access will be provided by Highway 45, which will be upgraded to Bonanza prior to Phase I. A new bridge across the White River will also be required if the White River Dam is constructed by the state of Utah.

3.4.3 SITE PREPARATION

Site preparation for surface facilities has been developed to minimize disturbed areas and earthwork and to establish an efficient, functional plan.

Site work for all drainage impoundment structures will involve removal of weak soils from the area proposed for dam construction. These soils can be used in constructing certain parts of the dam itself. Most of the material for the dam will come from the area to be inundated by the stored water.

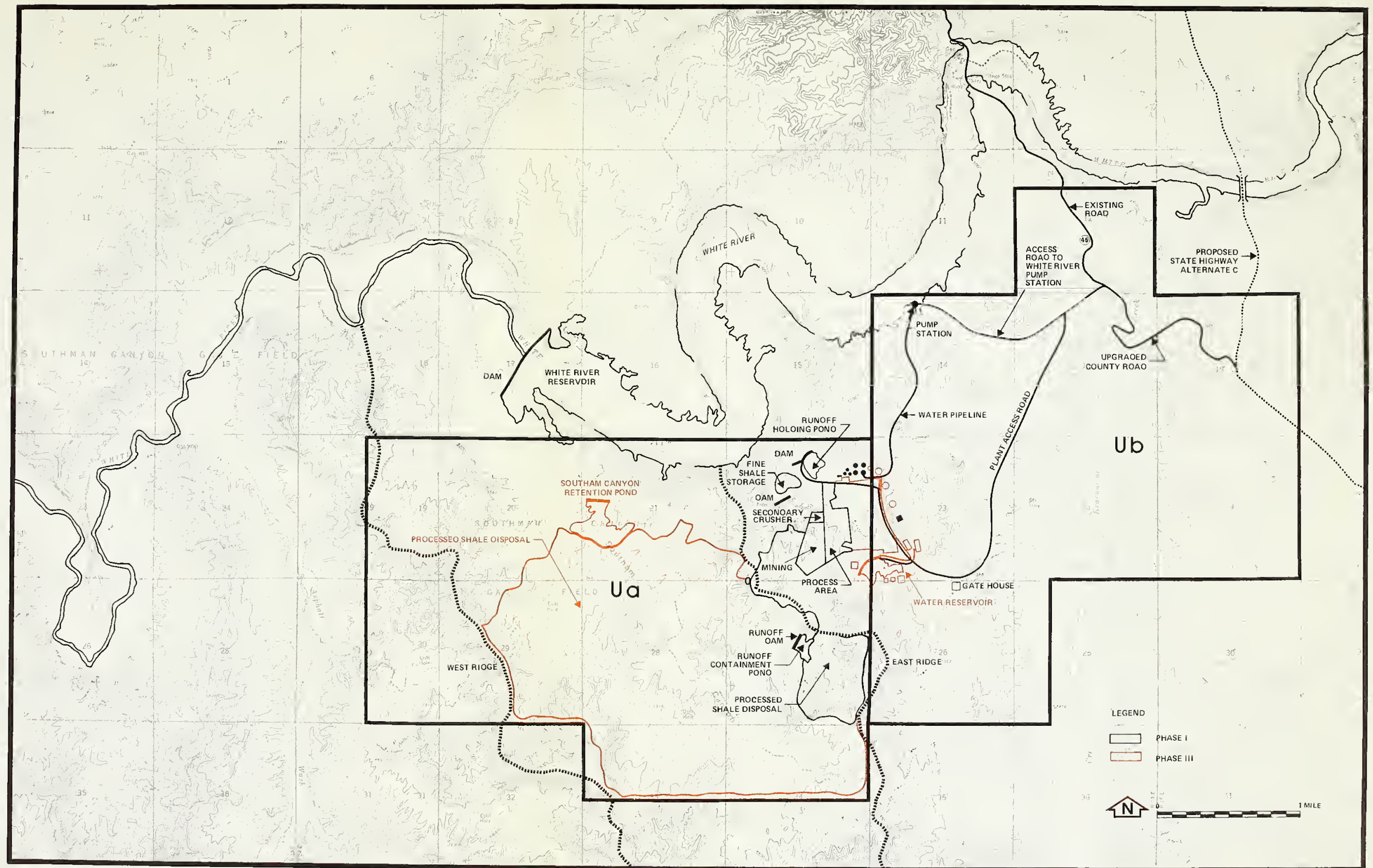


Figure 3.4-1 OVERALL SITE PLAN

LEGEND:			
PROCESS FACILITIES			
1 COARSE SHALE RETORT, DH (PARAHO)	•	•	•
2 COARSE SHALE RETORT, (UNION B)	•		
3 FINE SHALE RETORT (TOSCO II)		•	•
4 GAS SCRUBBER	•	•	•
5 SULFUR RECOVERY	•	•	•
6 ABSORBER AND STABILIZER	•	•	•
7 DESALTER	•	•	•
8 SOUR WATER STRIPPER	•	•	•
MINING AND MATERIAL HANDLING FACILITIES AND BUILDINGS			
A – MINE SERVICE BUILDING	•	•	
B – SECONDARY CRUSHER	•	•	
C – RAW SHALE STOCKPILE	•	•	
D – FINE SHALE STORAGE	•		
E – TREATED EFFLUENT AND STORM RUN-OFF HOLDING POND	•		
F – CONTROL ROOM	•	•	•
G – GENERAL BUILDING	•		
H – ADMIN. AND LAB. BUILDING*	•		
J – SHOP AND WAREHOUSE		•	
K – FIRE HOUSE		•	
L – ADMIN. BUILDING		•	
M – CAFETERIA		•	
N – PARKING LOT		•	
O – CHANGE ROOM AND LUNCH ROOM		•	
P – GATEHOUSE	•		
UTILITIES			
I BOILER AND POWER PLANT	•	•	•
II SUBSTATION	•	•	•
III COOLING TOWER	•	•	•
IV WASTEWATER TREATING	•	•	•
V RAW WATER TREATING	•	•	
VI TANKAGE	•	•	•
VII TRUCK LOADING	•		
VIII PUMP STATION**		•	
IX WATER RESERVOIR	•	•	
X COLD STORAGE	•		
XI FLARE	•	•	•
XII SULFUR STORAGE	•		
*WILL BECOME LAB FOR PHASE II.			
**PROVIDED BY THE OWNERS.			

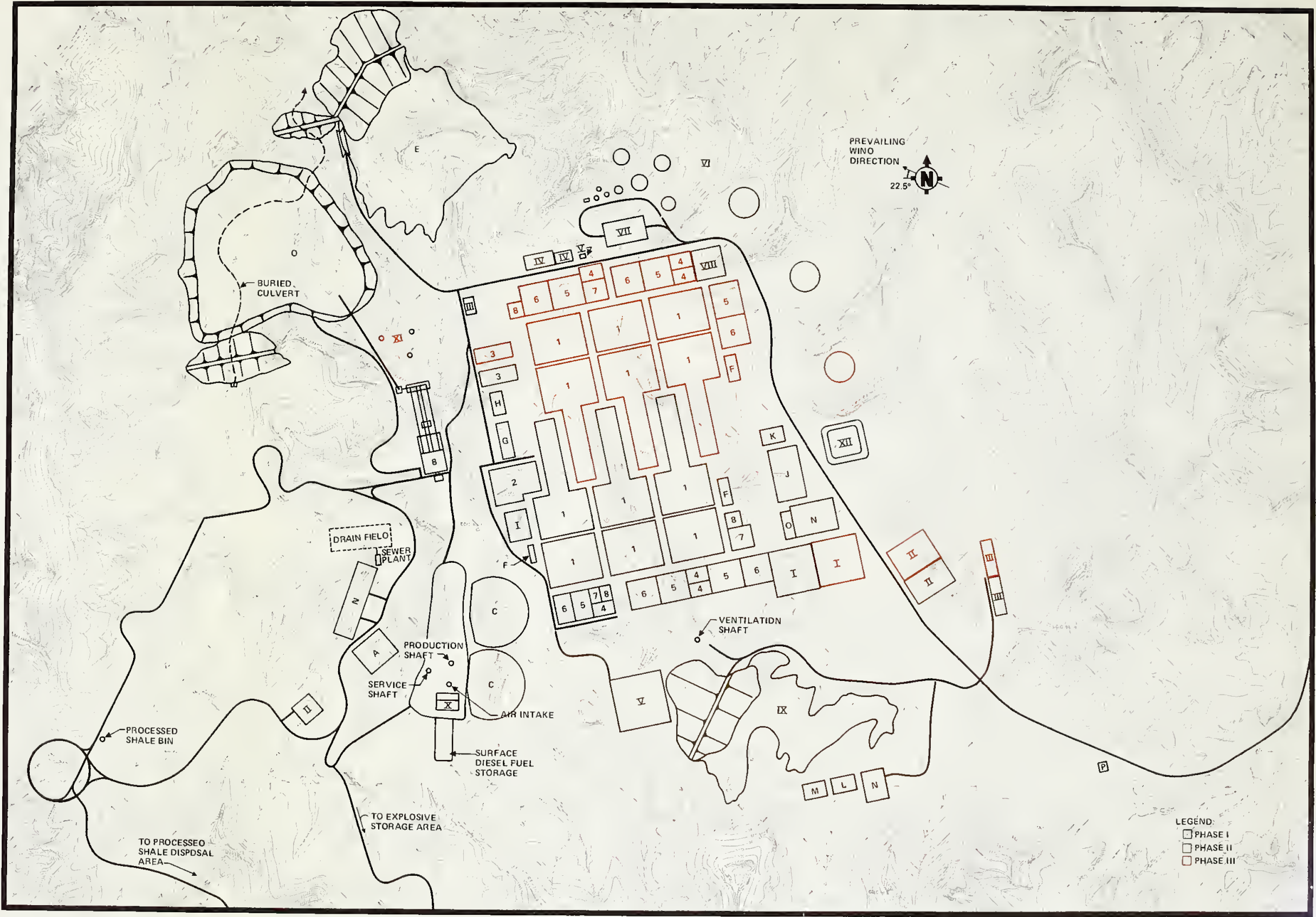


Figure 3.4-2 PROCESS AREA PLOT PLAN

Construction activities in each stage will disturb only limited areas other than those shown. These other areas will be for material storage and will be located outside temporary work areas.

3.4.4 WATER SUPPLY

The pumping station will be built near the bank of the White River, and a pipeline will be laid from the river to the on-site plant reservoir. From the plant reservoir, two pipelines will be laid, one for the process plant and one for the processed shale disposal area. The reservoir dam, constructed early in Phase II, will be located above the plant to minimize the need for additional pumping. During Phase I, water will be supplied directly to a storage tank in the process plant to eliminate the need for a plant reservoir.

3.4.5 MINE SHAFT LOCATIONS

Parameters considered when locating the Phase I shafts were the Ua and Ub Tract centroid, surface topography, prevailing wind direction, secondary crusher location, conveyor angles, and future expansion. Fortuitous topography enables the friction hoists to be mounted over the shaft at the surface elevation, thereby avoiding the construction of costly headframes and making tunnel access possible between the service building and the service shaft.

3.4.6 OIL SHALE HANDLING

The raw oil shale will be hauled to the underground primary crusher; it will then be transported to the surface via vertical shafts in Phase I and also via conveyors in the mine inclines in Phases II and III. The most efficient removal of oil shale requires the inclined entries to be located close to the retorting facilities.

At the portal, the oil shale will be transferred from the inclined conveyors to the aboveground conveyors. These two aboveground feeder conveyors will intersect with the main conveyor, which will transport the primary crushed shale to the secondary crusher. Another conveyor will take the secondary crushed shale into the process plant. Adjacent to these conveyors will be a stockpile for primary crushed shale. This stockpile will be used in Phases II and III for buffer storage of shale to balance differences in daily operating rates of the process plant and the mine.

3.4.7 PROCESS AND SUPPORT FACILITIES

The proposed processing plant will be built slightly north of the midpoint between the two oil shale deposit centroids and oriented to allow shale to enter the southwest corner of the plant for minimal conveyance, within the constraints of the terrains and the location of other facilities. Since oil products and wastes will exit from the north end of the plant, the main oil pipeline, tankage, wastewater collection pond, and waste processing facilities will be situated in this area. This area will be generally downhill from the plant, and the locations of the runoff collection ponds will contain and control contaminated storm runoff and oil spills.

On the east side of the plant will be the maintenance buildings, boiler house, general operation support facilities, and electric power generators. This area will be used heavily for logistics support and will therefore be the best location for the main access road.

3.4.7.1 Phase I

In Phase I, two retorts will be installed for 14,930 BPSD of raw shale oil production capacity. The retorts will be constructed at the southwest corner of the main process plant area since the entry of oil shale is at that point. To support these retorts, small buildings will be built along the west edge of the future main plant area. These buildings will be converted to other uses in later phases. Additional facilities to be installed in

Phase I include boilers, waste processing facilities with reduced capacity (for later expansion), eight tanks, a truck loading facility, and the runoff collected ponds. No product pipeline is anticipated in Phase I since the raw oil product will be trucked out.

3.4.7.2 Phases II and III

During Phases II and III, Process Trains 1 and 2 will be constructed for 109,770 BPSD of raw shale oil production capacity, along with electric power generators and all support facilities described above. In addition, an administration complex will be built on the south side of the plant, near the plant reservoir.

An oil pipeline will be installed, exiting eastward from the north end of the plant. Three more storage tanks will also be built.

3.4.8 PROCESSED SHALE DISPOSAL

As shown in Figure 3.4-1, the processed oil shale will be disposed of in the Southam Canyon area immediately adjacent to the main process area. This canyon provides a suitable fill area for the processed shale and a location for a retention dam that will prevent contaminated runoff from entering the White River.

During Phase I, a conveyor will carry processed shale to a bin southwest of the retorts for removal by truck to Southam Canyon. During Phases II and III, processed shale will be taken from the process plant on conveyor southwestward, to a location near the edge of Southam Canyon for optimal placing in Southam Canyon.

3.5 MINING

3.5.1 MINE DEVELOPMENT PROGRAM

The commercial oil shale mine to be developed on Tracts Ua and Ub is designed in three phases of production capacity: Phase I up to 26,700 TPSD, Phase II up to 95,700 TPSD, and Phase III up to 178,500 TPSD. Figure 3.5-1 shows a graph of proposed oil shale production versus time. An underground room-and-pillar mining method has been selected as the most economical and suitable way of extracting the oil shale. The assumed average grade of shale to be mined is 28 gallons per ton.

The geology of the proposed mining zone has been described in three other reports, and so it is not summarized here. For detailed information on mine geology, refer to Preliminary Rock Mechanics Report (Ref. 3-2), Geologic Exploration Program Report (Ref. 3-3), and Geophysical Logging Report (Ref. 3-4).

3.5.1.1 Phase I

The goal of two-retort operation in Phase I is to bring into production a mine capable of providing up to 26,700 TPSD of oil shale. A production shaft, service shaft, and air exhaust shaft, all 28 feet in diameter, will be sunk in the vicinity of the Ua-Ub centroid. The ventilation system will provide 2,000,000 cfm of air to the mine operation.

The proposed hoisting system will be driven by a friction winder mounted over the shaft at ground level and powered by large electric motors. The production shaft will contain two 33-ton-payload skips in balance. The service shaft will contain one counterbalanced man-and-materials cage capable of handling loads of 25 tons. Skip loading will be by automatic

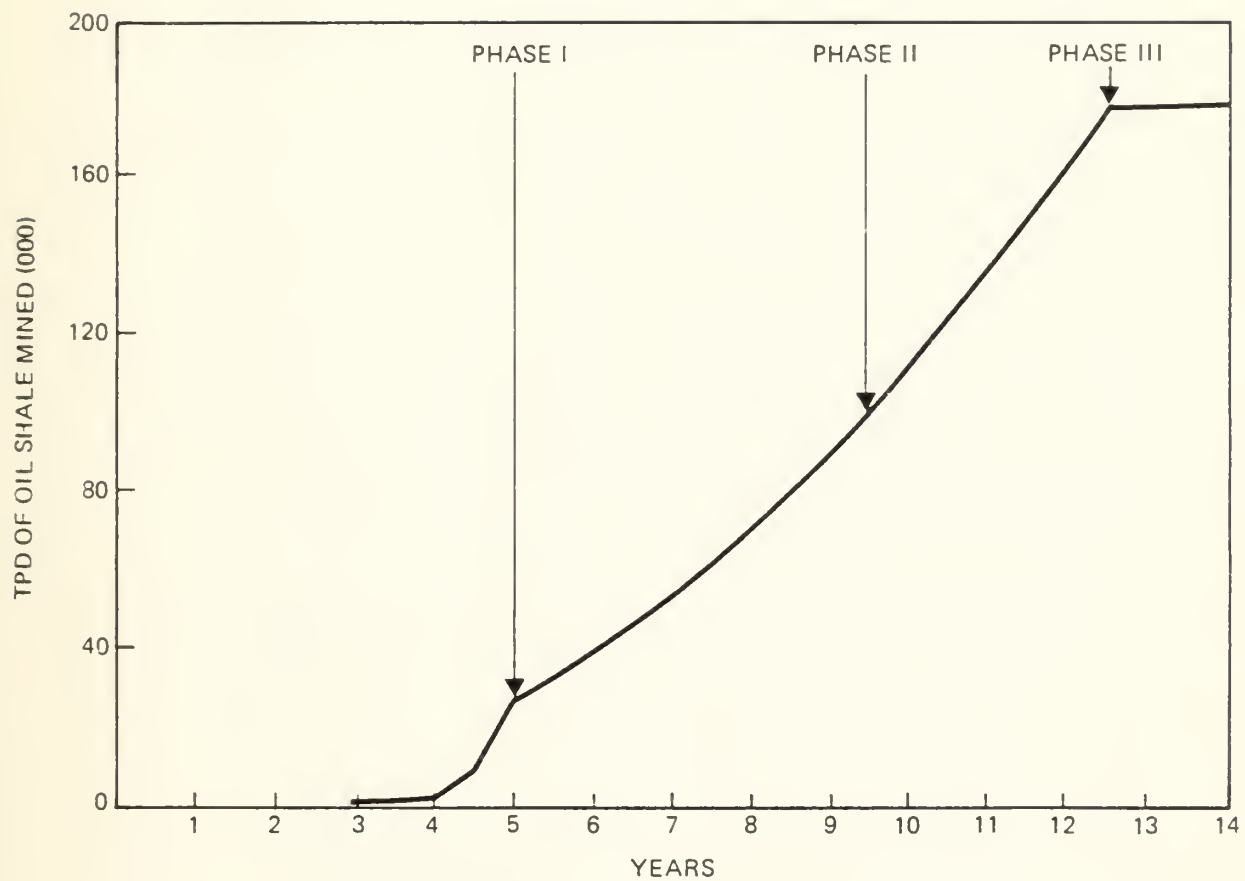


Figure 3.5-1 MINE PRODUCTION

measuring pockets, and the skip cycle time will be 79.1 seconds. Cycle breakdown is as follows:

Load/dump	14.8 seconds
Accelerate	14.1 seconds
Constant velocity	21.1 seconds
Decelerate	16.7 seconds
Creep	<u>8.4</u> seconds
Total	79.1 seconds

The production and service shafts will also serve as ventilation air intakes. Shaft diameters were dictated by ventilation requirements and breakdown dimensions of underground equipment. A third shaft, 28 feet in diameter, will serve as the exhaust air course, with shaft size dictated by ventilation requirements.

Preproduction mine development will consist of driving entries to mining areas, and to shop, warehouse, primary crushing, and ore handling facilities. All associated facilities, including ventilation and utilities distribution, will be completed during this development phase. Initial mine development will proceed in an easterly direction.

Mine site surface construction will include hoisting facilities, fan installation, a changehouse, an office, a parking lot, shops, explosives magazine, and storage yard. All surface shaft and production areas will be adequately fenced for security and safety reasons.

These developmental activities will take 4 years to complete, culminating in a mine production rate of 26,700 TPSD. Panels will be developed and mined east of the shaft locations during this phase. Figure 3.5-2 shows the shaft and panel layout for the Phase I operation of 26,700 TPSD.

3.5.1.2 Phase II

The Phase II operation will require a mine production rate up to 95,700 TPSD. Development to reach this level of production will continue

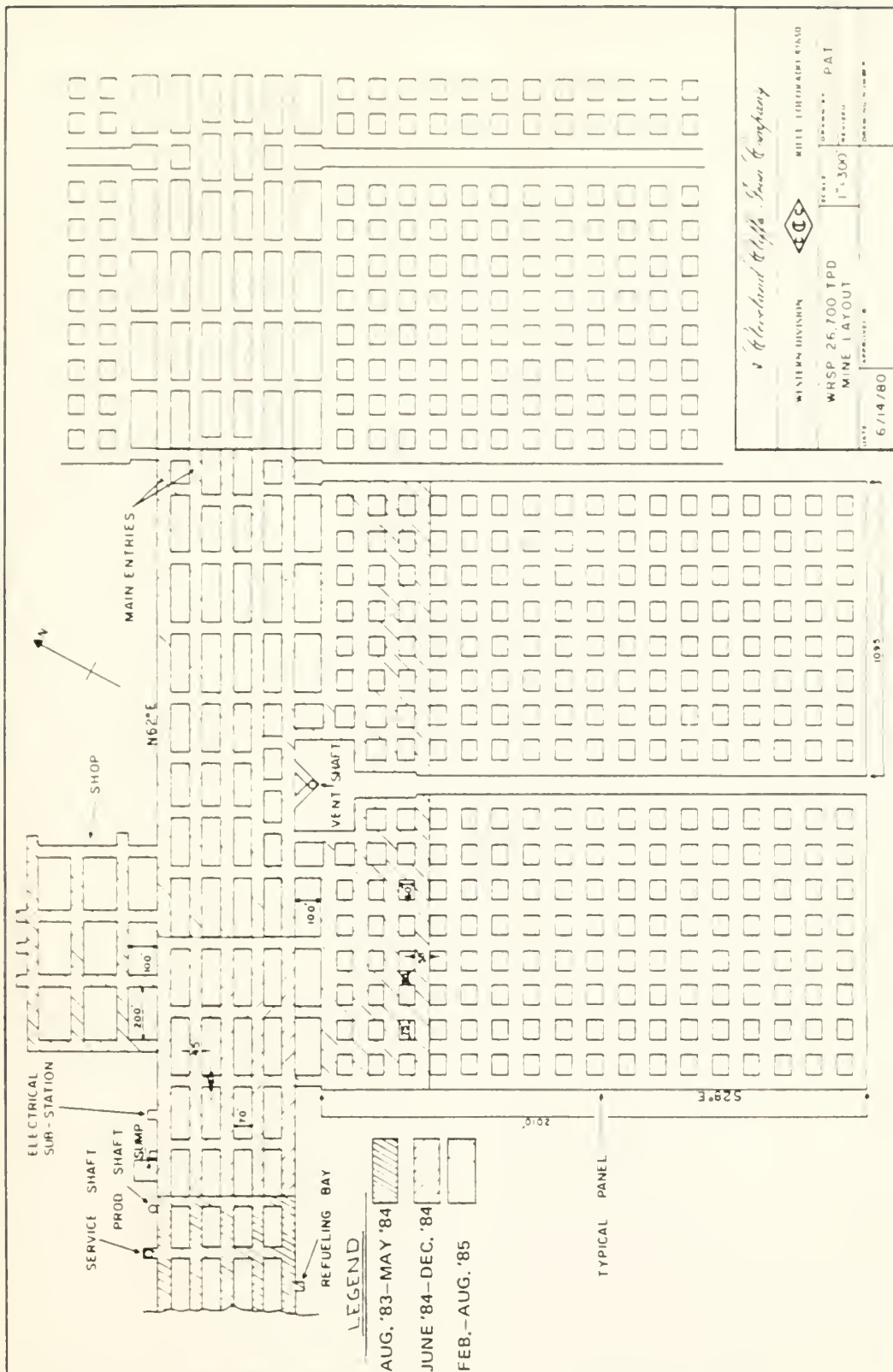


Figure 3.5-2 PHASE I MINE LAYOUT

northeast toward the centroid of Tract Ub. Presently planned is an incline between the surface and the mining horizon to serve as a beltway for moving the additional Phase II tonnage to surface. The Phase I production shaft will continue to be used for hoisting up to 30,000 TPD, and the Phase I service shaft will continue to serve as a man-and-materials hoisting facility. Depending on ultimate ventilation requirements, a maximum of up to four ventilation shafts will be sunk in the Ub area to provide up to 4,000,000 cfm of additional air for the expanded operation. Additional underground shop and warehouse facilities may be constructed near the centroid of Tract Ub to serve as a satellite shop area for Phase II mining activities. Minor maintenance will be done near the working panels. Surface structures will be located to conform with the surface topography as well as to fit the pattern of underground workings.

During Phase II, panel mining will progress outward from the Ua-Ub centroid, and mining will proceed concurrently within four or five panels. The ore produced will pass through a primary crusher before being conveyed or hoisted to the surface for secondary crushing and retorting. The construction and mine development stage of Phase II operations will last approximately 4 years. Development ore will feed the commercial stage retorts, and the surplus will be stockpiled.

3.5.1.3 Phase III

Phase III operations will increase the production rate to an ultimate 178,500 TPSD. An inclined beltway will be driven westward from the plant area to the mining zone and from there on toward the centroid of Tract Ua. Up to six shafts will be sunk outside the Southam Canyon drainage system to allow delivery of up to 6,000,000 cfm of ventilating air to the mine. These shafts will not be near the Ua centroid, which lies in Southam Canyon, because that area will be used for processed shale disposal. The Phase I production and service shafts will continue to be used during Phase III. The general mine layout for Phase III is shown in Figure 3.5-3.

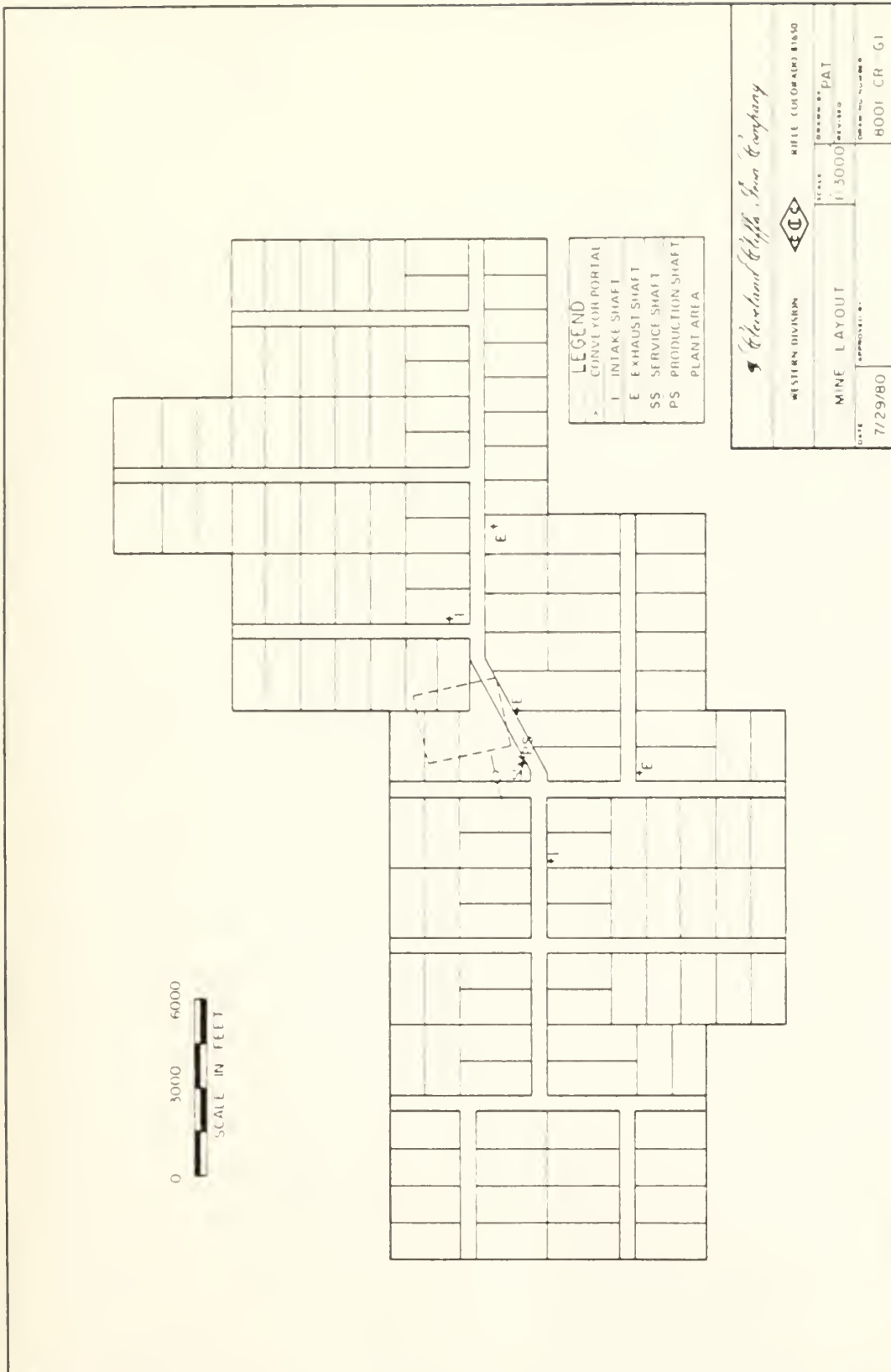


Figure 3.5-3 PHASE III MINE LAYOUT

All mining activity will follow the same pattern as the Phase II operating phase. Production is projected to continue at the 178,500 TPSD rate until the reserves are depleted.

3.5.2 MINE DESCRIPTION

The following paragraphs describe the surface and underground facilities, means of access, the primary mining function, and optional haulage systems.

3.5.2.1 Surface Effects and Facilities

The surface effects of developing the mine will be limited to the required shafts, portals, and their ancillary structures for hoisting and ventilation, access roads, changehouse, office facilities, shops, explosives magazines, and storage yard. The explosives magazines will be built in a safe location in accordance with existing state and federal regulations. Most of the mine maintenance facilities will be underground. Proper design of the support pillars left intact in the room-and-pillar mining method will minimize surface subsidence. Material from shaft sinking will be used for fill and grading around the surface facilities. The location of surface facilities is shown in Figure 3.5-4.

3.5.2.2 Shafts and Ventilation System

Vertical shafts will provide access to the mining zone in Phase I. These shafts will be located in accordance with underground requirements and overall surface layout. All applicable regulations pertaining to a gassy mine environment will be complied with.

In Phase I, all men, materials, and ore will be vertically hoisted. In Phases II and III, conveyor declines between surface and underground will be added to the ore transport system. The production and service shafts, along with other designated shafts, will serve as air intake shafts, as required. Exhaust shafts with surface-mounted fans will be part of the

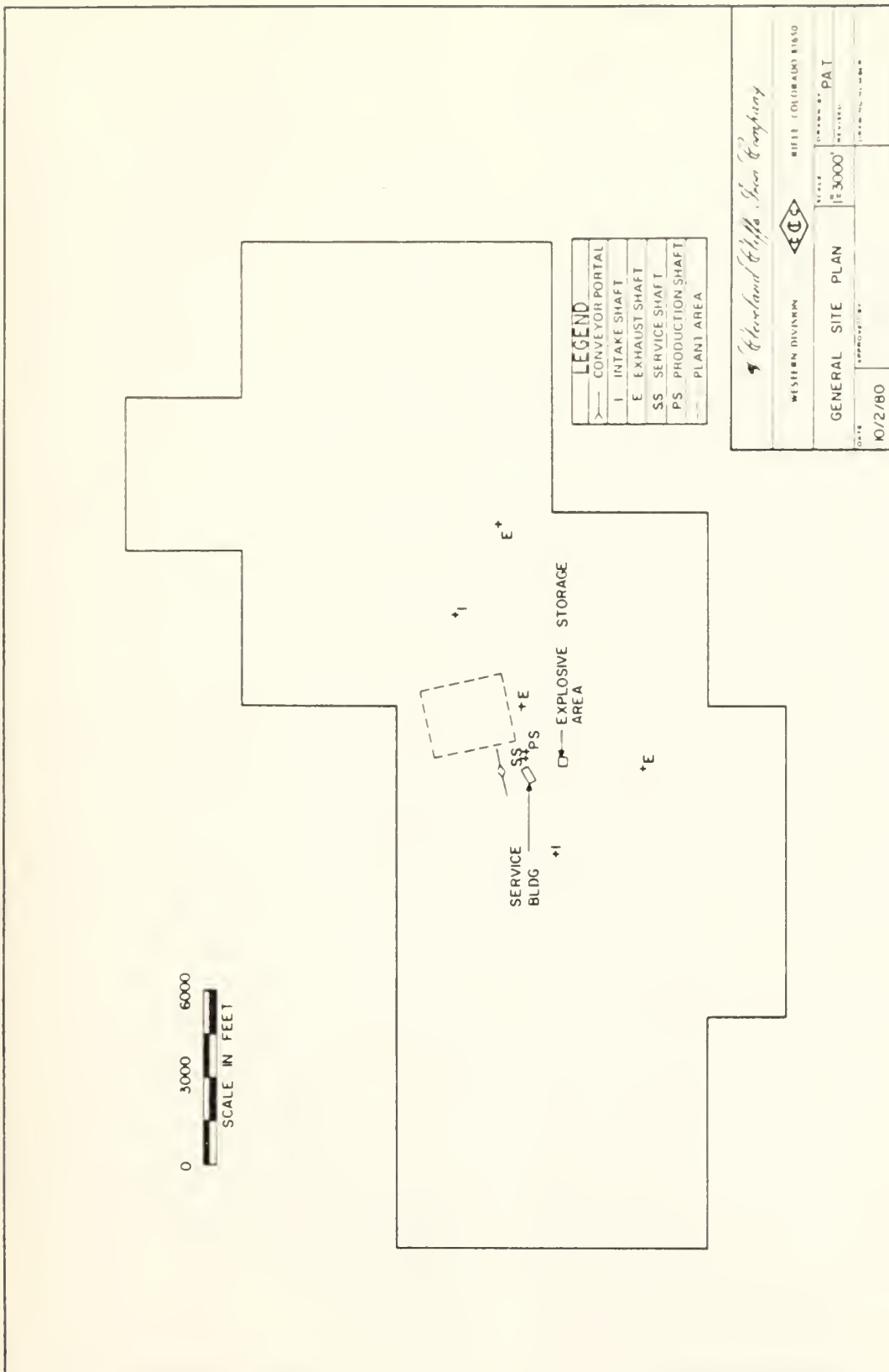


Figure 3.5-4 GENERAL SITE PLAN

ventilation system. The ventilation shafts will be circular and will probably be lined, with diameters consistent with ventilation requirements. The man-and-materials service shaft will be large enough to allow the mining equipment to be lowered into the mine without cutting basic components. An exhaust ventilation system of the type used in a typical room-and-pillar coal mine is planned. The air will be drawn down the intake shafts; delivered to the working areas by the use of stoppings, overcasts, undercasts, brattice lines, regulators, and secondary fans as require; and exhausted through vertical shafts by fans mounted on the surface. Auxiliary fans will be used in the working areas.

Each working area will have its own fresh air supply in quantities sufficient to meet all statutory requirements for air quality and velocity. Abandoned areas may be sealed or ventilated by a bleeder system, depending on the final use of the area.

Fans will be offset from the shafts and will be provided with explosion-proof doors and all other required safety and alarm features. Underground structures will be nonflammable and will be designed to direct the air effectively to the working areas. Air quality and quantity will be continuously monitored. A typical ventilation system for a panel is illustrated in Figure 3.5-5.

3.5.2.3 Mining and Work Plan

A two-bench room-and-pillar system is proposed as the most appropriate mining method. The upper-bench height will be 15 feet, while the lower-bench height will average about 40 feet. A typical configuration is shown in Figure 3.5-6. The mine will be divided into panels consisting of 9 rooms and 15 or more crosscuts. The panels will be separated by barrier pillars as part of the ventilation and roof support system.

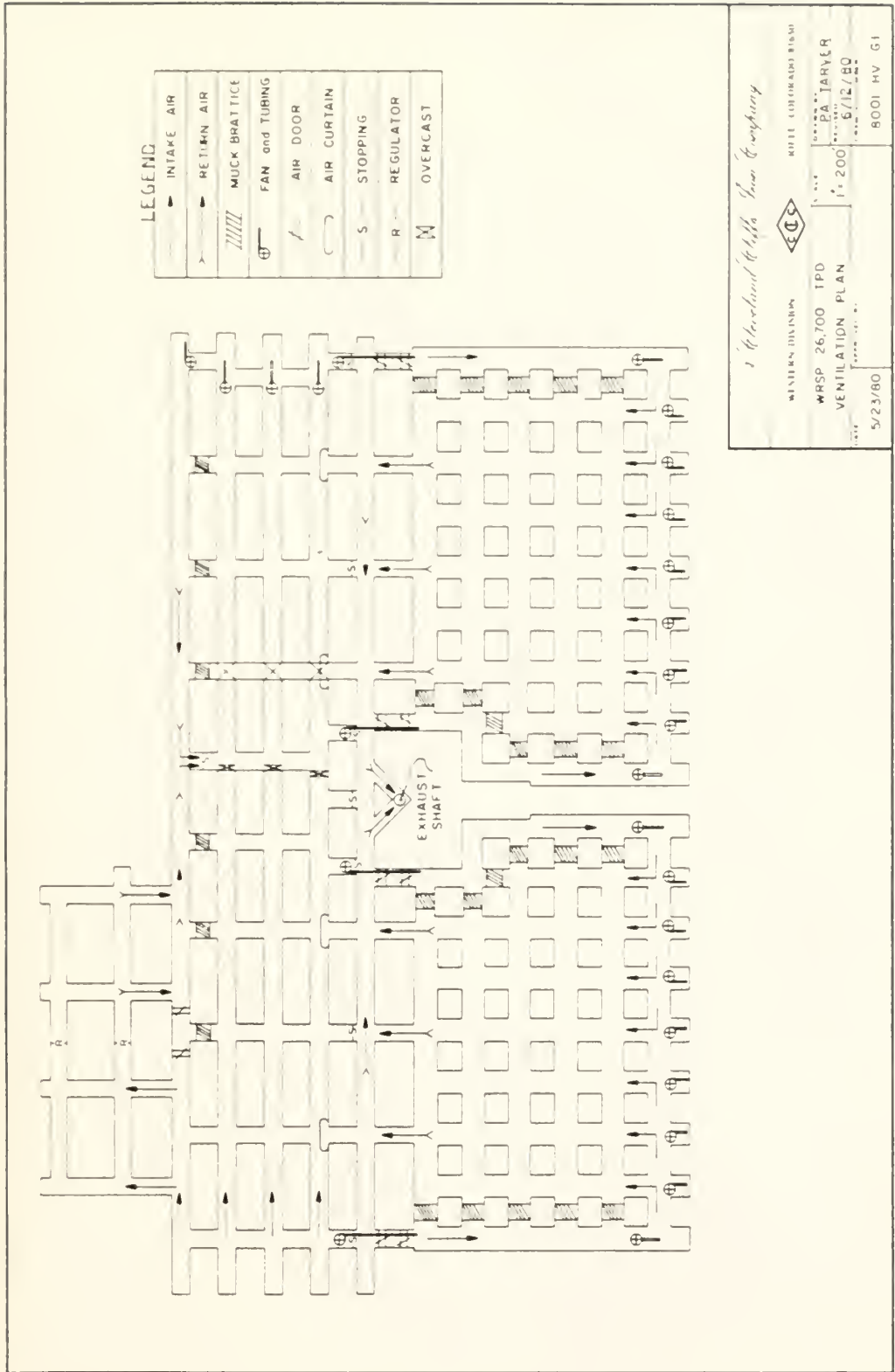


Figure 3.5-5 PHASE I VENTILATION PLAN

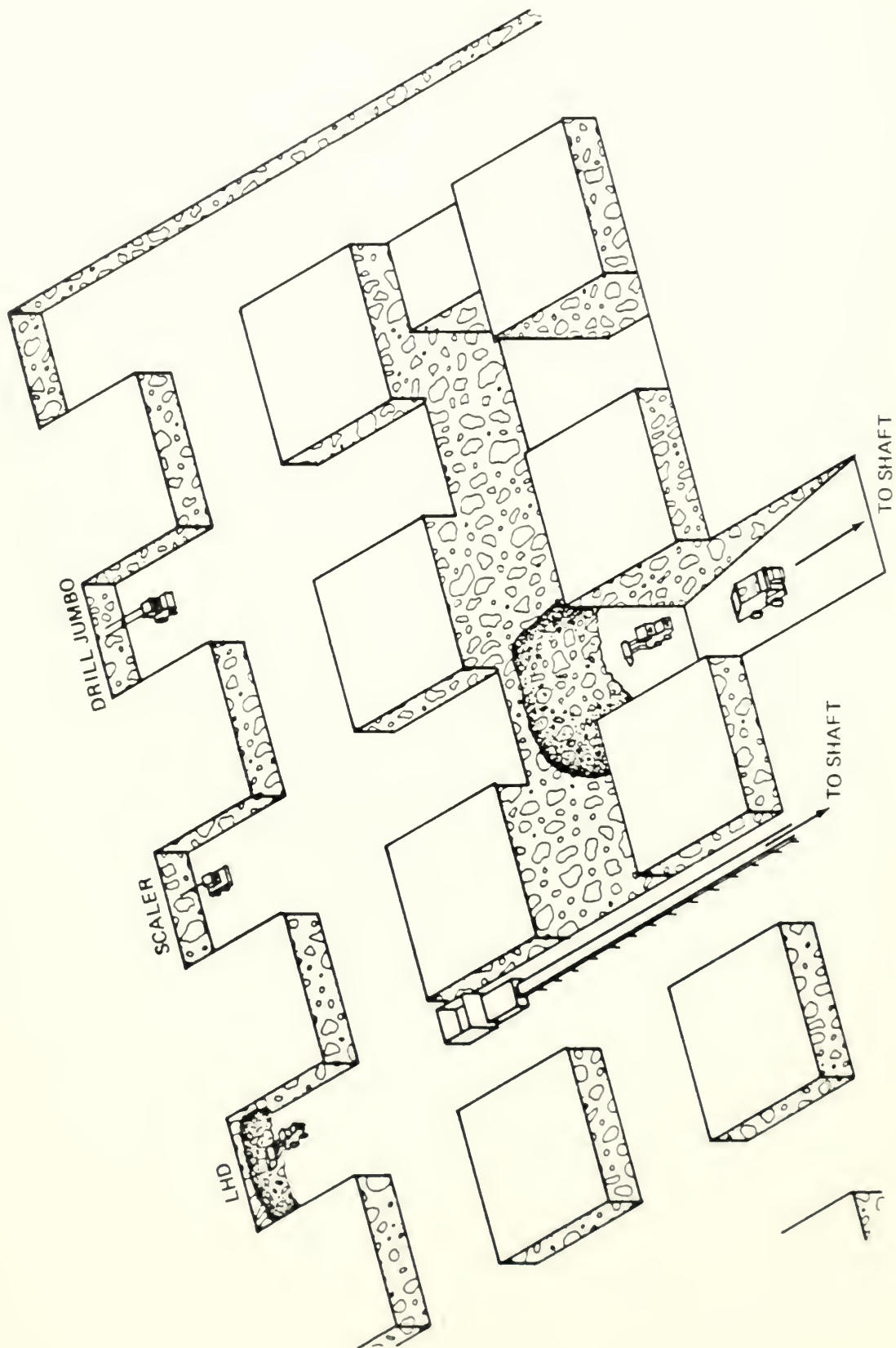


Figure 3.5.6 ROOM-AND-PILLAR TWO-BENCH MINING SYSTEM

All entry and mine development drifts will be approximately 30 feet high in the upper portion of the mining zone. Lower benches in the panels will be developed with ramps from the entry system.

A five-entry development system will provide access to the mining panels. Three of the entries will provide air intake, haulage, and service activities; the remaining two will serve as return air courses.

On the basis of preliminary rock mechanics test work and a 3.5 pillar safety factor, rooms and crosscuts 55 feet wide and entries 45 feet wide are planned. Pillar dimensions within the panels will be 60 by 75 feet. Entry pillars will be 70 feet wide, and their length will be determined by panel access requirements and the statutory maximum distance between crosscuts. Initial panel mining will be on the 15 foot upper level and will proceed approximately 400 feet before the 40 foot lower-level mining begins. A distance of 400 feet will be maintained throughout the operation. Rock mechanics studies indicate that the overall resource recovery will be approximately 63 percent of the defined mining horizon, with recoveries as high as 70 plus percent in the panels.

Conventional drilling, blasting, loading, hauling, scaling, and roof bolting techniques will be employed in the proposed mining plan. Specialized drilling equipment, scaled up to fit the large-sized openings, will be required.

Drilling. Drilling will be accomplished with commercially available drill jumbos capable of drilling 3-inch-diameter or larger horizontal holes up to 22 feet deep. The drill units will use diesel for tramming and electric/hydraulic power for drilling. Electric power will be supplied through a trailing cable. A 750 scfm compressor for drill-hole cleaning and water-detergent tanks for dust suppression will be mounted on the carrier. The drill operators will work in enclosed, acoustically insulated cabs.

Charging and Blasting. Each drill hole will be primed with a high-strength primer that contains a millisecond-delay electric blasting cap. The ammonium nitrate-fuel oil (AN/FO) blasting agent will be placed pneumatically in the drill holes. All explosive and detonation devices will conform to statutory requirements. The charging carriers will be equipped with pressure pots, PTO-driven compressors, and elevating platforms for charging the 15- to 40-foot-high headings. The pressure pots will hold sufficient explosives for one shift of charging activity.

The leg wires from caps in each heading will be interconnected and subsequently tied into a blasting trunkline. Blast initiation will be accomplished with an electric detonating system. Most blasting will be done during the period allowed for shift changes.

Loading and Hauling. The blasted material will be loaded into conventional haul trucks with diesel-powered, front-end loaders or into permissible load-haul-dump units and hauled to a belt loading point. In all cases, the equipment will have exhaust conditioners and air-conditioned and accoustically insulated cabs with adequate protection against rollover and falling objects. The haulage system is discussed in greater detail in Subsection 3.5.2.4.

Scaling. Loose rock will be removed from the roof, ribs, and face with a mechanical scaler capable of reaching all potentially loose material while allowing the operator to remain in a safe location.

Roof Bolting. A systematic pattern of roof bolts will be used to support the exposed roof as required to ensure the safety of mining personnel. It is presently proposed that split-set bolts be installed on approximately 5 foot centers. The roof-bolting machine will be self-contained with a water-detergent tank for dust control and a 60 cfm air compressor for purging holes. The drill carriage and attached bolt cassette will index about a common point, permitting automated bolting from a remote operator's panel near the back of the machine.

Support Activities. All support equipment and vehicles will be diesel powered with exhaust conditioners. Maintenance and warehousing facilities will be centrally located underground.

3.5.2.4 Haulage System

Load-haul-dump units will haul upper-bench material to feeder breakers from which conveyors will transport the material to skips or inclines. Lower-bench material will be hauled by truck to a central crusher site in conventional diesel haulage trucks. Two entries will be devoted to production haulage and will be well lighted, with one-way traffic for safety and efficiency. Alternate methods that may be used subsequently are described in Section 7.5. Phase I operation will have a production shaft to hoist crushed material to the surface. Phases II and III will add conveyor belts to move material from the crusher stations to a surge bin area and thence to surface. The conveyer inclines to surface will be sloped at approximately 15 degrees.

3.5.2.5 Dewatering System

Present information indicates that mine drainage will not be a problem. Water encountered will be pumped to strategically located underground storage facilities and used for dust suppression in various stages of the mining operation. Excess mine water will be pumped to the surface from underground storage sumps. Water pumped from the mine will be discharged into the wastewater holding pond, as described in Section 3.15.

3.5.2.6 Mine Utilities

Utilities required for the mining operation are shown in Table 3.5-1 for mining rates of 26,700 TPSD and 178,500 TPSD.

Nonpotable water for dust and fire control will come from mine drainage and, if needed, from surface. Potable water will be piped into the mine and distributed to points accessible to the work force.

Table 3.5-1

MINING OPERATION UTILITY REQUIREMENTS

Utility	Phase I 26,700 TPSD	Phase III 178,500 TPSD
Potable water (acre-ft/yr)	20	82
Nonpotable water (acre-ft/yr)	150	925
Electricity (kW)	14,000	66,000

Chemical toilets will be used in the mine, and wastes will be disposed of in the surface sewage facility. Trash will be collected systematically and transported to the surface for disposal.

Electricity will be supplied at 13.8 kV to the fans and underground areas by power cable routed down either the service shaft or a separate borehole.

In an effort to minimize potential fire hazards, underground diesel fuel storage will be limited to a 5,000 gallon day tank. An aboveground metering system, controlled by probes in the 5,000 gallon tank, will limit the amount of diesel fuel piped into the mine at one time. Additional safety features include a containment structure around the underground tank, an automatic fire protection system, and fail-safe valving to halt flow into the mine tank in the event of a spill or rupture.

A telephone system will be installed for intramine and mine-to-surface communication. The intramine system will be a five-channel system with a paging channel.

3.5.3 MINE SAFETY

The mine and ancillary facilities will be designed, constructed, and operated in accordance with the State of Utah Metal and Nonmetal Health and Safety Standards and with the Federal Metal and Nonmetallic Mine Safety Health Act.

A comprehensive program of safety indoctrination, training, and retraining will be an integral part of the mine operating plan. Planned safety contacts, on an individual and group basis, will supplement the regular safety meetings and random contacts that are common to most safety programs.

Mining personnel will be trained in underground evacuation and survival. Alternative escape shafts are planned, and travel ways will be maintained and posted for emergency use. An emergency warning system will be installed that may be any one or a combination of audible, visual, or olfactory alarms. Self-rescuers and other standard personal safety equipment will be mandatory for all people going underground. Provision of mine rescue apparatus and training is also part of the overall safety program.

All mobile equipment will be supplied with the devices needed to provide a safe working environment for the operators, and the maintenance program will be designed to keep all equipment in safe operating condition. Protection against rollover and falling objects will be furnished where applicable, and self-contained fire extinguishing systems will complement the standard portable extinguishers. Lockout and barricading programs will be enforced.

A fire prevention program for the underground mine area will center on training and proper housekeeping. All workers will be trained to recognize potential fire hazards and to correct them. Trash will not be allowed to accumulate, but will be systematically removed from the mine and disposed of at the proper surface facility. Equipment will be properly maintained to reduce the chance of fire. Flammable commodities will be stored only in limited quantities in fire-resistant structures; diesel fuel will be stored on the surface, except for the underground day tank.

Stationary units will be equipped with self-contained fire extinguisher systems, and portable fire extinguishers will be placed at strategic locations. All water trucks will have hoses and nozzles for fire fighting,

and a foam-type fire truck will be included in the program. All workers will be trained in fire-fighting techniques.

Roof bolts will furnish the primary roof support, and the rooms and pillars will be designed to keep spans within the limits of the roof strength and mine design safety factors. A continuing program of inspection, monitoring, and testing will ensure good roof conditions. Periodic scaling of the ribs in active workings will remove loose rock, and the mined-out areas will be sealed or barricaded and posted against entry.

Blasting agents will be brought into the mine in bulk. Underground magazines used for boosters, detonators, and blasting agents will conform to all state and federal regulations.

3.5.4 VEGETATION REMOVAL PROGRAM

The surface facilities for mine support will be generally small and scattered and will disturb only about 50 acres of the 10,240 acre lease area. Vegetation is sparse and soil cover thin on the upland areas selected. Standing vegetation will be shredded in place with a rotary mower. Topsoil will be graded into the existing terrain or used as appropriate.

3.5.5 MINE WASTEWATER CONTROL

Mine drainage is expected to occur in small amounts and to be of a quality acceptable for dust suppression and other uses within the mine, thus proportionally reducing freshwater (or treated wastewater) requirements. If enough mine drainage occurs to require pumping from the mine area, it will be disposed of by the methods discussed in Subsection 3.5.2.5.

3.5.6 MINE AIR EMISSION CONTROL

The mining operations of drilling, blasting, scaling, loading, transferring, and unloading will generate air pollutants. Particulates will result from all basic mining activities, and gaseous pollutants will be created

by blasting and underground use of diesel engines. Diesel engine combustion products and blasting fumes, along with minor amounts of methane, welding fumes, and dust, will compose the principal emissions from the mine. However, effective measures will limit the accumulation and emission of pollutants to the atmosphere (see Section 4.2).

The following control measures will be employed to minimize dust:

- During drilling, water and wetting agents will be applied at the drill bit to control dust.
- Muck piles of blasted shale may be wetted before loading to minimize dust generation. Wetting agents may be used if they prove effective in reducing water requirements or in improving dust control.
- Truck haulage routes will be maintained using conventional road wetting and chemical stabilization techniques.

The principal gaseous air pollutants resulting from diesel engine exhaust and from blasting will be carbon monoxide, nitrogen oxides, and hydrocarbons. The engines will be maintained regularly as the most positive means of limiting emissions. All diesel engines will be equipped to meet federal air emission standards for underground operation. Where feasible, mining equipment will be provided with enclosed cabs for the comfort of the operators.

The mine ventilation system will remove blast fumes and dust from working panels as quickly as possible by immediately directing it into the exhaust air system. Because of the large openings and low ventilating current velocities, dust probably will not be transported over long distances in the return air courses, but will settle out. If more effective measures are required, additional water sprays will be installed near the bottom of the upcast shafts, or ventilation air will be passed through mined-out panels to reduce velocities and increase settling time.

Dust and fumes caused by blasting will be diluted and effectively removed from work areas by fresh air from the mine ventilation system. Fumes will be minimized by selecting a blasting agent compatible with hole conditions (wet or dry) encountered while drilling.

Estimated emission rates of air pollutants and their effects on ambient air quality are discussed in Sections 4.2 and 5.2.

3.5.7 MINE NOISE CONTROL

A method of noise control will be required in the underground mine. Equipment design will include the latest technological advances in sound suppression, and additional operator protection will be provided in the form of insulated cabs wherever possible. A room-and-pillar configuration will aid in reducing line-of-sight noise propagation from one working area to another. Other underground noise sources will be neutralized by using individual ear protection devices. Normally, blasting will take place during shift changes to minimize exposure to that source of noise. The blasting crew itself will be protected by a combination of distance from the blast and the use of ear protection devices.

Because of the variable nature of their work, personnel engaged in support activities will be subjected to differing noise levels. Most of these activities, however, will be carried out in areas where equipment noise will not be excessive. Individual ear protection will be provided where required.

Ventilating fans will be the principal source of noise on the surface, but these will be located so as to minimize impacts on workers and fauna habitats.

3.6 FEED PREPARATION AND MATERIAL HANDLING

The process of preparing the mined oil shale for retorting requires facilities for crushing and screening the raw shale, and for feeding it to the retorts. There will be three stages of crushing operations before retorting: primary crushing, which will take place underground, and secondary and tertiary crushing, which will take place on the surface near the retorts. The type of retort used will determine the size to which the oil shale must be crushed and screened. Covered conveyors will transport oil shale to secondary crushers, the stockpile area, bins, and retort feed hoppers; they will also move the processed shale to the disposal area.

Primary crushed oil shale will be stockpiled on surface at a location near the secondary crushing plant to ensure uninterrupted operation of the secondary crusher and continuous feed to the retorts. The underground mine haulage system and primary crushing operations will be interdependent. If the primary crusher is shut down, haulage from the mine will be stopped; the secondary crusher will then be fed from the stockpile.

3.6.1 FEED SPECIFICATION

The oil shale will be broken into pieces smaller than 12 inches, a size suitable for hoisting and traveling on the conveyor belts, in the primary crushing step underground. On surface, further crushing together with screening steps will reduce this ore to appropriate sizes for retorting. Coarse-shale vertical-type retorts will require feed material sized either plus 1/8 inch by minus 2 inches or plus 1/2 inch by minus 3 inches; fines-type retorts could process the fines smaller than 1/2 inch. The operations required to produce such a suitable feed are described in the following paragraphs for the three project phases.

3.6.2 PHASE I OPERATIONS

Phase I retorting will require 26,700 TPSD of shale. The operations described to provide this shale to the retorts in Phase I include primary crushing, stockpile and reclaim, secondary and tertiary crushing and screening, material handling, and dust control. A material handling flow diagram for Phase I is shown in Figure 3.6-1.

3.6.2.1 Primary Crushing

The primary crushing station for Phase I will be located underground at the mining level. The crushing facility will consist of one unit capable of crushing up to 1,000 TPH of scalped material. Over-design of the crushing system is due to the 48 inch chunk size it must handle.

A toothed, single-roll crusher is proposed for primary crushing to suit the capacity and product size requirements of the plant. Roll crushing is recommended because it creates less fines and dust with this particular material than do other methods available.

Haulage units will dump onto a grizzly where plus 48 inch material will be separated for secondary breakage by a hydraulic impact tool. A 250 ton hopper below the grizzly will receive the minus 48 inch feed. A hydrostroke feeder under the hopper will supply a 48 by 72 inch McLanahan type toothed, single-roll crusher, which will reduce run-of-mine rock to a minus 12 inch primary product. The primary product will drop into a 3,900 ton live storage bin from where two 48 inch apron feeders will meter material onto two 54 inch conveyors for delivery to two skip loading pockets.

The minus 12 inch crushed product will be transported by a mine hoist through a vertical shaft to the surface where belt conveyors will transport coarse shale to the secondary crusher or a conical stockpile.

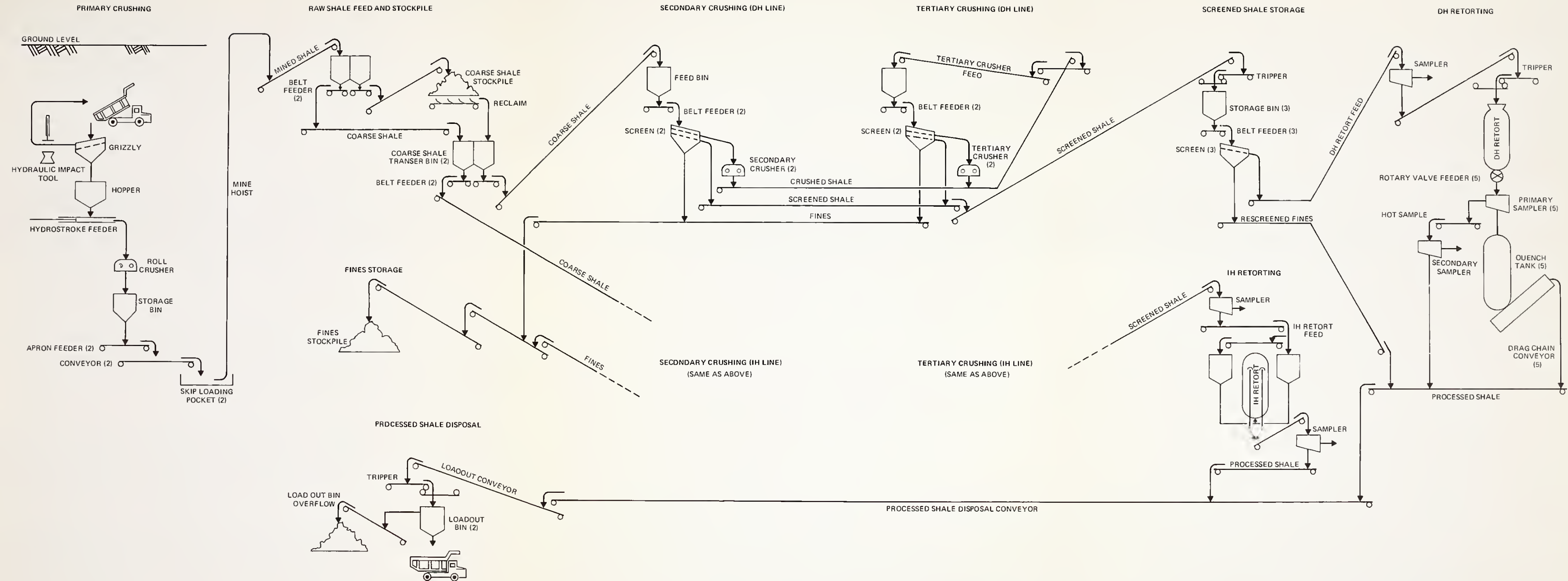


Figure 3.6-1 MATERIAL HANDLING SYSTEM
FLOW DIAGRAM, PHASE I

3.6.2.2 Stockpile and Reclaim

After being hoisted to the surface, primary crushed material will be conveyed to the secondary crusher or a conical stockpile located between the production shaft and the secondary crushing plant. This raw oil shale stockpile will be in the open and of an appropriate size to support retort operations for several days. (The present estimate is approximately 400,000 tons.) A stockpile placement structure will suppress dust during the stockpiling operation.

Oil shale will be drawn from the stockpile by apron feeders onto a belt conveyor within a reclaim tunnel. A dust collection system will be provided at the reclaim tunnel. The coarse shale stockpile and reclaim system provides surge capacity between the mine and crusher facilities.

3.6.2.3 Secondary and Tertiary Crushing and Screening

For Phase I, the crushing and screening plant is designed to produce crushed oil shale of the required size for the DH (plus 1/2 to minus 3 inches) and IH (plus 1/8 to minus 2 inches) vertical-type retorts. It is designed to process sufficient tonnage for Phase I in two lines of secondary crushers, tertiary crushers, and vibrating screens. Each screen and crusher unit is spared-up by a parallel unit to ensure feed to the retorts on a 24 hour basis.

For the DH vertical-type retort, coarse (minus 12 inch) oil shale is reclaimed by the belt feeder from the coarse shale transfer bin and is conveyed to the secondary crusher feed bin. There, it is reclaimed by belt feeder and fed to an 8 foot by 20 foot double-deck vibrating screen fitted with a 3 inch square opening screen cloth on the top deck and a 1/2 inch opening screen cloth on the bottom deck.

The plus 3 inch top-deck oversize discharges to a 30 inch by 60 inch second-day roll crusher. The roll crusher discharges to a belt conveyor and then

the shale is transported by a series of conveyors to the tertiary crusher feed bin. A belt feeder reclaims the secondary crushed oil shale and delivers it to an 8 foot by 20 foot tertiary double-deck screen fitted with the same screen surface as the secondary screen. The plus 3 inch screen oversize reports to the tertiary roll crusher. The crusher discharge is transported by the same series of belt conveyors back to the tertiary feed bin. The plus 1/2 inch by minus 3 inch bottom deck product from the secondary and tertiary screens discharges to the final product belt conveyor, which transports the product to the DH retort. The minus 1/2 inch fines are transported by belt conveyor to the fines storage stockpile.

The crushing and screening line that prepares feed for the IH retort is identical to the DH line except for the screen cloth used on the secondary and tertiary vibrating screens. The screens in the IH crushing line are fitted with a 2 inch opening top deck and a 1/8 inch opening bottom deck. The minus 1/8 inch fines are transported by belt conveyor to the fines storage stockpile.

The crusher building initially will house the equipment for the 26,700 TPSD Phase I plant. Provision will be made for future extensions to accommodate the equipment for the Phase II and III plants. Overhead cranes and servicing facilities will be furnished at the crushing plant. Auxiliary equipment will include an extensive dust collection system, cleanup sumps and pumps, and ventilating fans.

Equipment items for each line of the secondary crushing facility will be designed as full-sized units. These pieces of equipment will be used for the Phase II plant and, eventually, for the full-sized Phase III facility.

3.6.2.4 Material Handling

The plus 1/2 inch by minus 3 inch product from the crushing and screening plant will be transported down the centerline of the future line of retorts

to the screened shale storage bin conveyor. From there, it will be discharged into any of three bins by a travelling tripper. These bins will provide four hours of storage to ensure that the supply of shale to the DH retort meets the stringent tolerances on feed rate, average grade, size, and moisture content. The shale will be reclaimed by belt feeders, rescreened to remove any fines generated in handling, sampled, and conveyed to the retort feed conveyor. This conveyor will deposit the shale, by a travelling tripper, onto a shuttle conveyor that travels with the tripper car, and then into the retort feed hoppers.

For the IH vertical-type retort, the plus 1/8 inch by minus 2 inch product from the second line in the crushing and screening plant will also be conveyed down the centerline of the future retorts, but will be transferred through a sampler directly onto the IH retort feed conveyor. This conveyor will deposit the shale onto a shuttle conveyor and thence into the retort feed hoppers.

At the DH vertical-type retort outlet, the processed shale will be discharged at an average temperature of 400F. It will drop into a quenching tank which will cool it to below 200F. Each tank will be half full of water and provide five minutes of retention time for the shale. The tank will be sealed and under negative pressure so that the dust and steam generated by the cooling can be collected and passed through a Venturi scrubber for cleaning and condensing. The slurry, condensate, and make-up water will be recycled to the quenching tank. The quenched shale and the slurry precipitate will be dragged out of the bottom of the quenching tank by a chain flight conveyor and deposited on a processed shale collecting conveyor, which will transfer it onto the processed shale disposal conveyor.

Processed shale from the IH retort will be discharged at 240F and saturated with water. The processed shale will be deposited on the processed shale collecting conveyor, and then discharged, via a sampler and belt scale, to the processed shale disposal conveyor.

3.6.2.5 Dust Control

Shale crushing will be a major source of dust, both underground and on the surface. The primary crusher dust control system will include ventilation and water spray for suppression. Dust will be drawn down through the crusher feed hopper and discharged into the mine air exhaust stream.

The exhaust system used for the primary crusher also draws dust-laden air from the crusher discharge apron feeder and from a portion of the underground conveyor system. All point where shale is either moved from one conveyor to another or discharged will be enclosed. All of the surface conveyors will also be enclosed. Water spray facilities will be used as required.

A stockpile placement structure will suppress dust at the stockpile. Each secondary and tertiary crusher-screen will be equipped with a wet scrubber for dust control. The retort and loadout bins, as well as all conveyor systems, will be enclosed to control dust.

These dust control facilities and procedures will be used in all phases of the project.

3.6.3 PHASE II OPERATIONS

Phase II retorting requires up to 95,700 TPSD of oil shale. (Phase I facilities will continue to operate during Phase II.) A material handling flow diagram for Phase II is shown in Figure 3.6-2.

3.6.3.1 Primary Crushing

The primary crushing facilities for the Phase II mining operation will consist of three, toothed, single-roll crushers, one at the production shaft and two at the base of the number one incline. The crushing rate is 3,000 TPH of screened material. Over-design is due to the 48 inch chunk size.

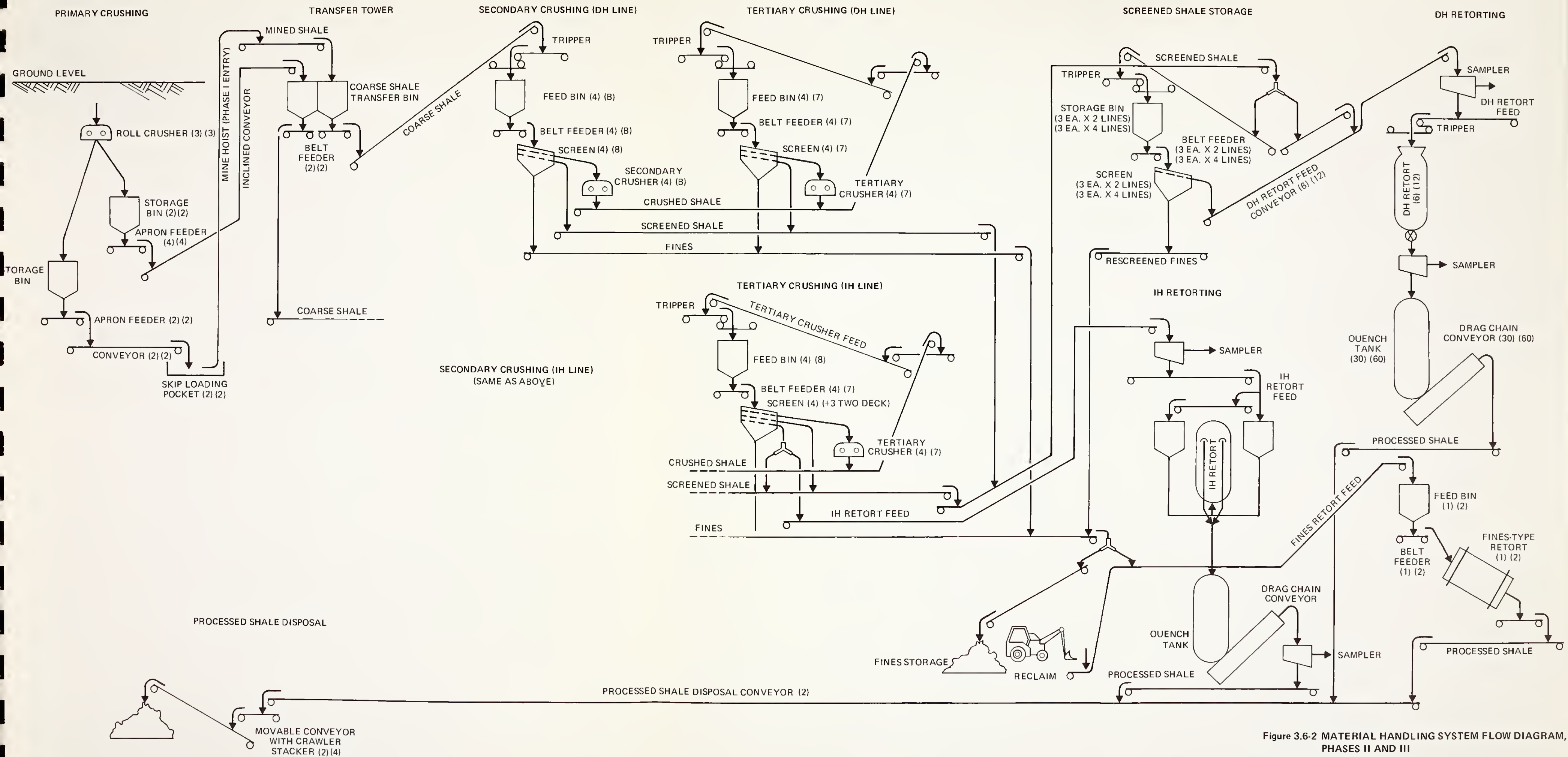


Figure 3.6-2 MATERIAL HANDLING SYSTEM FLOW DIAGRAM, PHASES II AND III

The flow of material from primary crushing to retorting is shown in Figure 3.6-2.

The minus 12 inch primary crushed product will be transported by skip hoist and belt conveyors to the secondary crusher or the coarse shale stockpile on the surface.

Auxiliary equipment will include dust suppression and collection systems.

3.6.3.2 Stockpile

On the surface, primary crushed shale will be conveyed to the secondary crusher or stockpiled near the secondary crushing plant. A tripper conveyor operating in an enclosed gallery above the stockpile will distribute the oil shale. This raw oil shale stockpile will be in the open and will be appropriately sized to ensure continued processing when the mine and primary crusher are shut down. The required Phase II stockpile size is currently estimated to be 1,200,000 tons.

Stockpiling will begin during the Phase I mine preproduction period and will gradually build up as mine development progresses.

Oil shale will be drawn from the stockpile by apron feeders onto a belt conveyor located in a reclaim tunnel where dust collection will be provided. A stockpile placement structure will suppress dust during stockpiling operations.

3.6.3.3 Secondary Crushing

For Phase II the crushing and screening is designed to produce 95,700 TPSD of crushed oil shale, sized as follows:

- 74,400 TPSD of plus 1/2 inch by minus 3 inch shale for the DH vertical-type retorts

- 11,600 TPSD of plus 1/8 inch by minus 2 inch shale for the vertical-type retort
- 9,700 TPSD of less than 1/2 inch shale for the fines-type retort

Raw oil shale of minus 12 inches is delivered to a transfer tower at the rate of 95,700 TPSD. A feeder delivers the shale on a belt conveyor to the tripper feed bin. This bin is also designed to receive oil shale delivered by a coarse shale belt conveyor, which transports shale from the raw shale stockpile. The tripper conveyor, in turn, feeds the secondary crusher feed bins. The oil shale is then reclaimed from these bins by eight belt feeders (one standby), which discharge to eight two-deck vibrating screens. These screens separate three products as follows:

- A coarse product, 3 to 12 inches, which passes through eight double-roll crushers that crush the shale to minus 3 inches
- The intermediate fraction, 1/2 to 3 inches, which falls on the retort feed bin conveyor
- The fines fraction, less than 1/2 inch, which is transported to the fines-type retort feed bin by a belt conveyor

The roll crusher discharge product is transported on a belt conveyor to the tripper belt which feeds the tertiary crushing feed bins. From these bins, the oil shale is reclaimed by seven tertiary belt feeders and screened on seven tertiary vibrating screens measuring 8 by 20 feet. Four of these screens have a triple deck and separate four products:

- The top deck (3-inch opening) removes the plus 3 inch fraction, which is then crushed to minus 3 inches by roll crushers. The minus 3 inch crushed product is reclaimed on the crushed belt conveyor and is returned to the tertiary crusher feed bin.
- The second deck (2-inch opening) scalps the crushed product to 2 inches in order to prepare the feed for the IH retort. The 3 to 2 inch fraction is discharged on the DH feed bin conveyor.

- The third deck (1/2 inch opening) separates the 1/2 to 2 inch fraction and it is transported to the IH retort feed bin.
- All the minus 1/2 inch fractions are transported on a belt conveyor to the fines-type retort feed bin.

The three other screens have only two decks, which separate a plus 3 inch fraction that is crushed in roll crushers, a plus 1/2 to minus 3 inch fraction that is discharged on the DH retort feed conveyor, and a minus 1/2 inch fraction that is discharged on the fines-type retort feed conveyor.

3.6.3.4 Material Handling

Raw oil shale will be discharged from the primary crushers into live storage bins. The ore will be transported to the surface through an inclined conveyor entry or through the vertical Phase I production shaft. Belt conveyors will transport material overland to the secondary-tertiary crusher or the coarse shale stockpile.

All conveyors transporting oil shale in Phase II between intermediate points — primary crusher, stockpile, secondary crusher, surge bin, and retorts — will be designed and built for use as segments of the ultimate Phase III capacity, which will be 178,500 TPSD. All auxiliary equipment, such as dust collection systems, servicing facilities, and control systems will be expanded to meet the requirements of the Phase III plant. To operate the plant with maximum efficiency and supervision, a system of instrumentation and controls that monitors the flow and provides equipment protection will be incorporated. All conveyors will be driven electrically and will be provided with required safety devices.

All surface conveyors carrying raw shale will be enclosed for dust control, and all transfer points and discharge points from conveyors to hoppers or bins or to other plant equipment will be of dust-confining construction. Dust suppression systems will be provided. Conveyors will be routed to

cover minimum distances with maximum permissible slopes. Roadways will be constructed along conveyor routes to facilitate construction and provide maintenance access.

3.6.3.5 Dust Control

The dust control facilities and procedures used in Phase I will also be used in Phases II and III.

3.6.4 PHASE III OPERATIONS

Phase III retort operation will require 178,500 TPSD of shale. The retort plant will use identical equipment to that installed for the Phase II plant and will operate on the same process flow. (Refer to Figure 3.6-2 for a diagram of material handling flow in Phase III.)

The total number of equipment lines for the primary and secondary crushing facilities and storage pile for the Phase II plant will be doubled to accommodate the Phase III mine rate. The primary crushing facility will consist of five units, all underground at mine level. The total crushing rate is 5,000 TPH of screened material. Over-design is due to the 48 inch chunk size.

Oil shale will be transported between intermediate points — mine portals, stockpile, secondary crusher, surge bin, and retorts — by the surface conveyor system used in Phase II. This system will, from its inception, be designed and built for the ultimate 178,500 TPSD capacity. All auxiliary equipment, such as dust collection systems, service facilities, and control systems, will be expanded to meet the requirements of the Phase III plant. To operate the plant with maximum efficiency and minimum supervision, a system of instrumentation and controls that monitors the flow and provides equipment protection will be incorporated.

3.7 RETORTING

This section discusses the retorting operations involved in a three-phase development program culminating in a commercial-size shale oil facility. Retorting equipment and products proposed for the Phase I two-retort operation are discussed, as are the ultimate products and types of retorts that will be needed for a full-scale commercial plant in Phases II and III. Flow diagrams and material balances associated with retorting operations in each of the two stages are included.

A detailed description of the various alternative retorting methods can be found in Section 7.

3.7.1 GENERAL RETORTING DESCRIPTION

The retorting program is designed in three phases of production capacity:

- Phase I, two-retort operation producing 14,930 BPSD of raw shale oil
- Phase II, commercial operation, single-train (multiple retorts), producing 58,740 BPSD of raw shale oil
- Phase III, full commercial operation, two-trains (multiple retorts), producing 109,770 BPSD of raw shale oil

The objective of Phase I is to evaluate and develop vertical-type retorts. A block flow diagram of Phase I retorting is shown in Figure 3.7-1. Fines produced during Phase I will be stockpiled for recovery and retorting during Phase III.

Phase II and III commercial retorting is diagrammed in Figure 3.7.2. The proposed use of three different types of retorts — direct heated, indirect heated, and fines-type — is based on specific process needs coupled with the requirement for high operating and thermal efficiency.

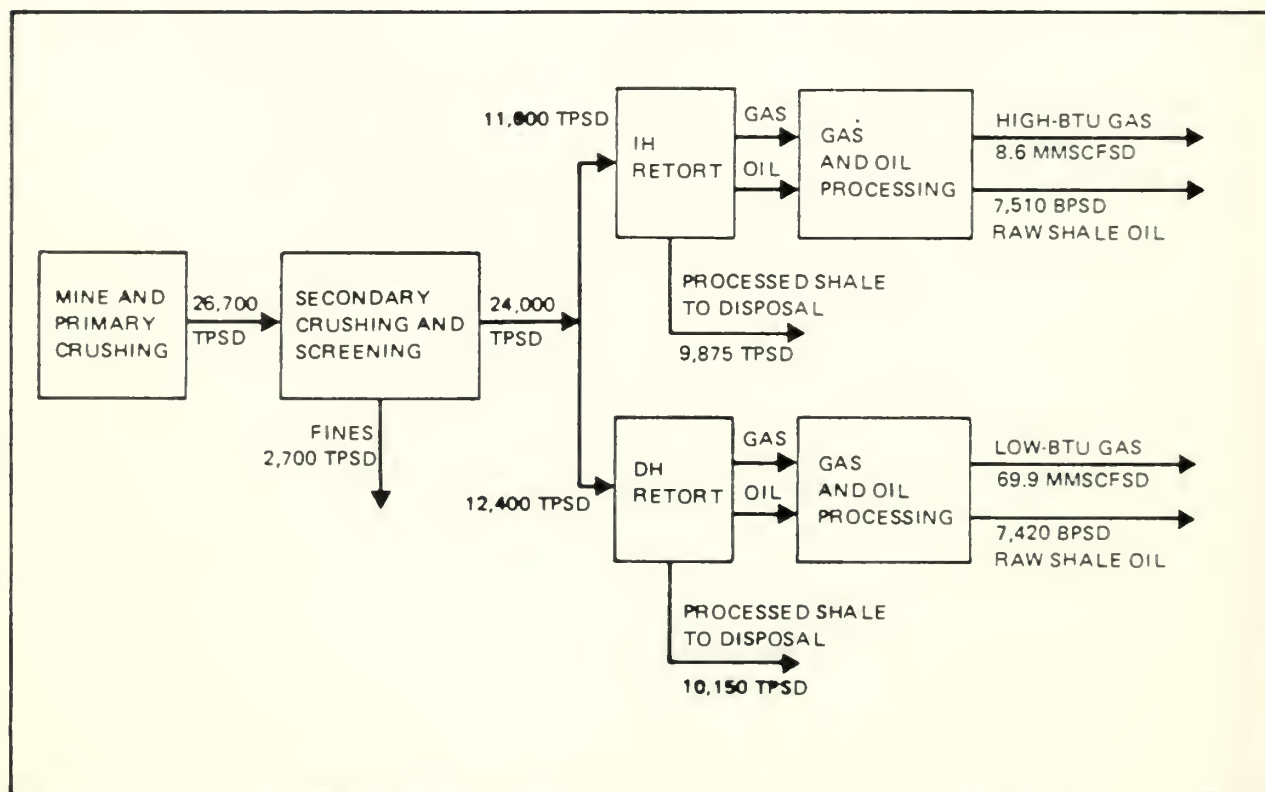


Figure 3.7-1 BLOCK FLOW DIAGRAM – PHASE I

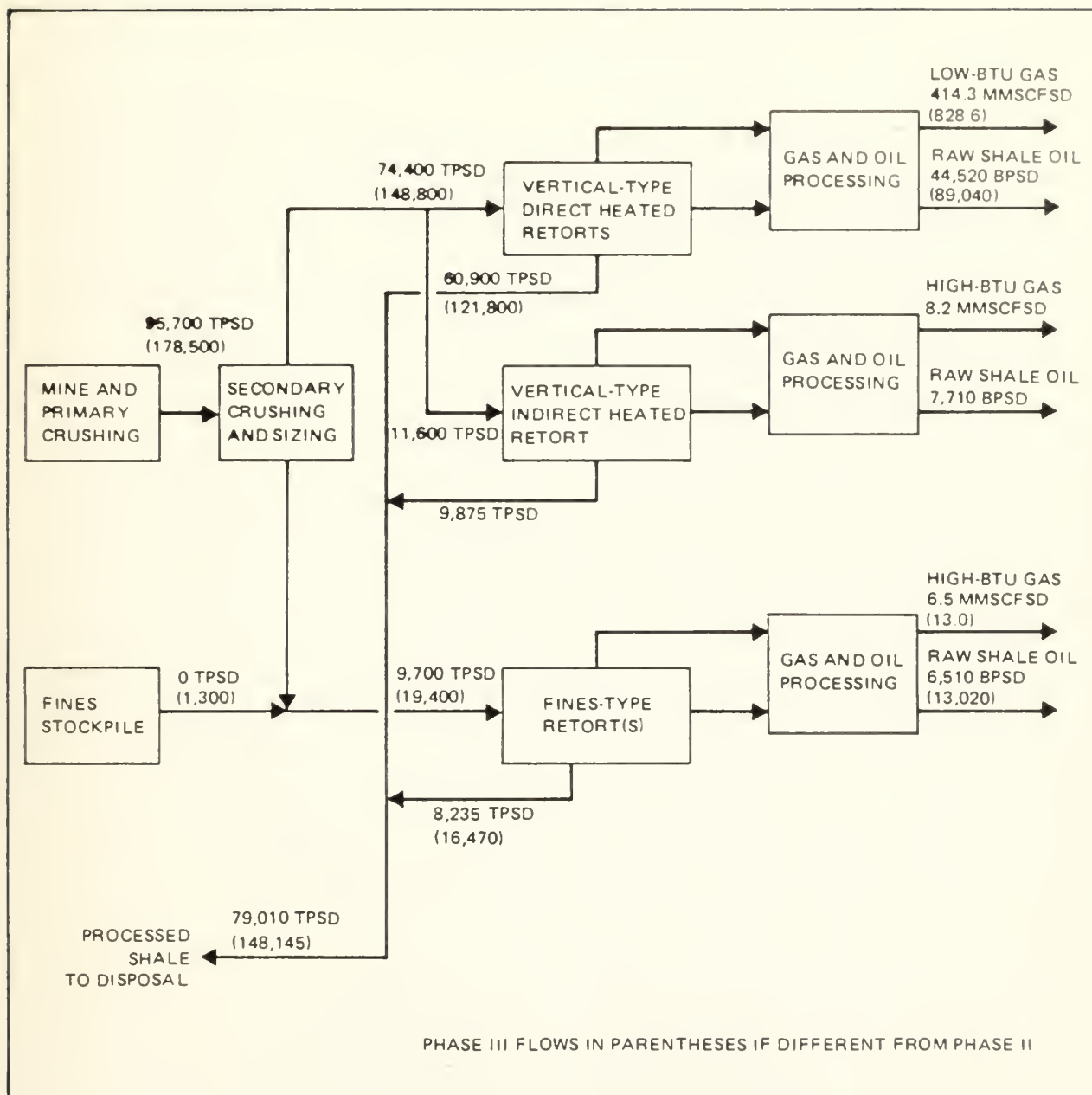


Figure 3.7-2 BLOCK FLOW DIAGRAM – PHASES II AND III

Table 3.7-1 presents material balances for each phase of the retorting program. It represents the combined inputs and outputs for all retorts.

Table 3.7-1
RETORTING MATERIAL BALANCE^(a)

Component	Phase I		Phase II		Phase III	
	TPSD	BPSD (MMSCFSD)	TPSD	BPSD (MMSCFSD)	TPSD	BPSD (MMSCFSD)
Retort Feed Shale	24,000	—	95,700	—	179,800	—
Air to DH Retorts	2,189	(57.8)	13,134	(346.8)	26,268	(693.6)
Total In	26,189		108,834		206,068	
Sour Water Stripper NH ₃ + CO ₂	34	(0.8)	204	(5.1)	408	(10.1)
Low-Btu Gas	2,778	(69.9)	16,541	(414.3)	33,082	(828.6)
High-Btu Gas	268	(8.6)	468	(14.7)	695	(21.2)
Raw Shale Oil (Dry)	2,436	14,930	9,539	58,740	17,825	109,770
Water (In Liquid Streams)	626	—	2,992	—	5,765	—
H ₂ S (To Sulfur Recovery Units)	22	(0.5)	80	(1.8)	148	(3.3)
Processed Shale	20,025	—	79,010	—	148,145	—
Total Out	26,189		108,834		206,068	

(a) Gas quantities shown are before consumption as fuel.

3.7.2 VERTICAL-TYPE DIRECT HEATED RETORT

Two modes of operation are possible with the vertical-type retort: direct-heated (DH) mode; and indirect-heated (IH) mode. In the DH mode, the heat of retorting is supplied by introducing air directly into the retort to burn the carbonaceous processed shale residue and a portion of the retort gas within the retort. Figure 3.7-3 is a schematic representation of the DH retorting system.

3.7.2.1 Mechanical Description

A general layout of the proposed vertical-type DH retort is shown in Figure 3.7-4. The significant items of equipment include the retort, the condenser, the precipitator, and compressors for air, recycle gas, and product gas.

3.7.2.2 Process Description

Raw shale from the feed bins is conveyed to the top of the retort, and then down through it. The rock is preheated by heat exchange with the ascending gas and oil mist. The shale then contacts recycle gas that has been heated by burning residual carbon from the processed shale. In this zone, the raw shale reaches temperatures sufficient to pyrolyze the organic kerogen.

The retorting temperatures are controlled to limit decomposition of mineral carbonates. In the bottom section of the bed, heat is recovered by cooling the processed shale through contact with a cool recycle gas.

The retort product gas, which contains oil mist, flows to a gas-liquid separation train. This train contains a spray tower, a coalescer, and an electrostatic precipitator. Recovered product oil flows to an oil surge drum from which it is pumped through a desalter to tankage.

The low-Btu product gas is compressed and treated to remove ammonia and sulfur compounds before being used as fuel.

The processed shale drops out of the bottom of the retort into a moisturizer, which cools the shale and suppresses the dust. Dust-laden steam and moist air produced in this step pass through high-efficiency wet scrubbers, where the steam is condensed and dust removed from the air. Clean warm air leaving the scrubbers is vented and the dust-laden steam condensate clarified for reuse. After cooling and dust suppression, the processed shale, with a moisture content of about 20 percent, is transported by conveyors to the disposal area.

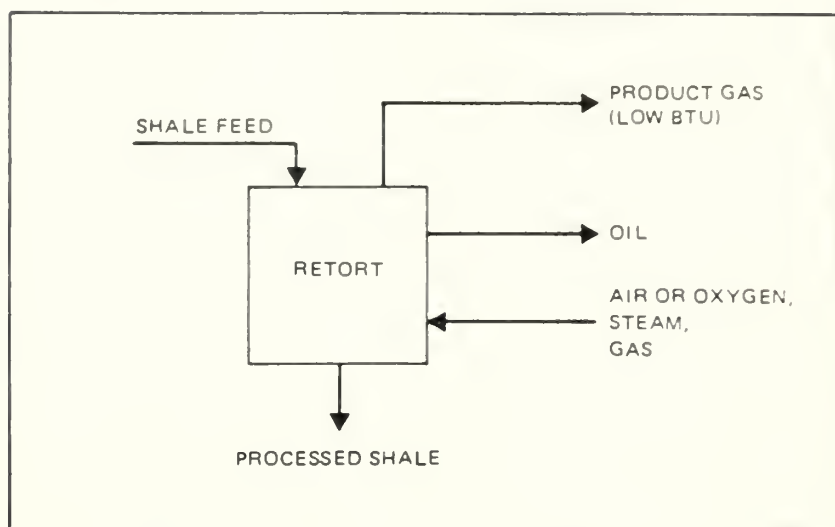


Figure 3.7-3 DIRECT HEATED(DH) RETORTING SYSTEM

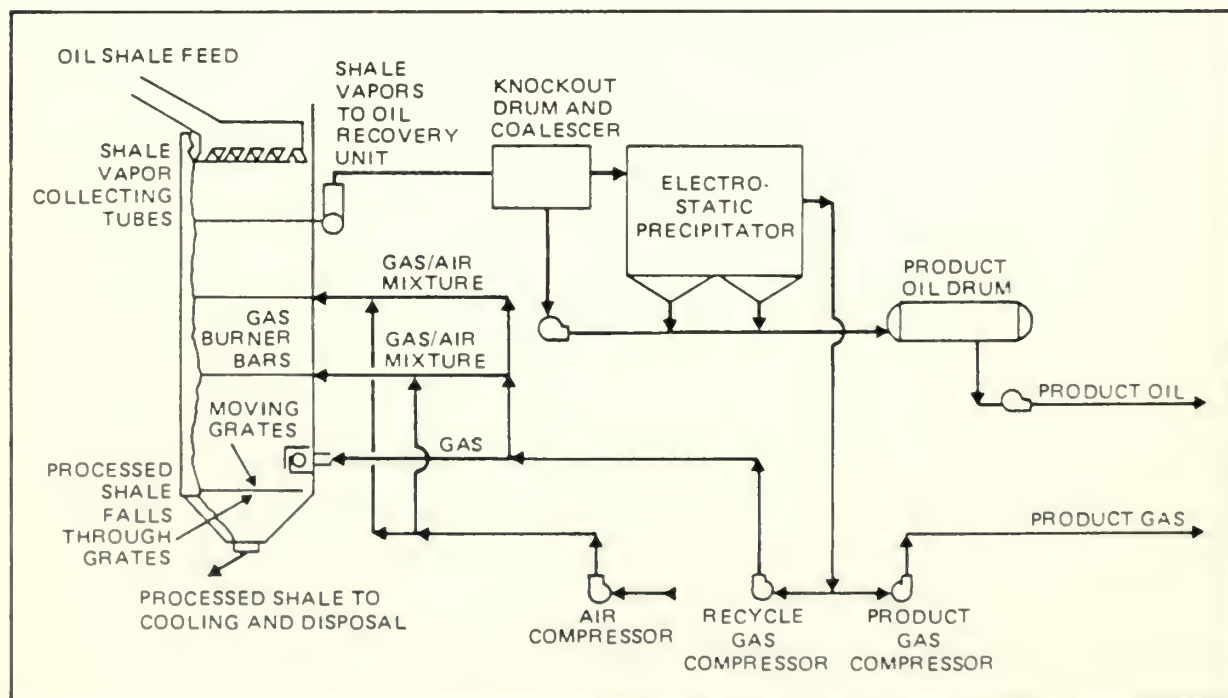


Figure 3.7-4 VERTICAL-TYPE DH RETORT

3.7.2.3 Product Characteristics

The estimated composition of the raw shale oil and low-Btu gas produced by the vertical-type DH retort is summarized in Tables 3.7-2 and 3.7-3.

Table 3.7-2

ESTIMATED COMPOSITION OF RAW SHALE OIL: VERTICAL-TYPE DH RETORT

Parameter	Value
Gravity, °API	21.4
Sulfur, wt %	0.50
Nitrogen, wt %	2.09
Distillation (ASTM D-1160)	
IBP, F	145
50, F	794
EP, F	1,100

Table 3.7-3

ESTIMATED COMPOSITION OF LOW-BTU GAS: VERTICAL-TYPE DH RETORT

Component	Vol % (Dry Basis)
H ₂	5.50
N ₂	60.97
CO	2.90
CO ₂	24.19
H ₂ S	0.30
NH ₃	0.60
C ₁	2.40
C ₂ 's	1.30
C ₃ 's	0.59
C ₄ 's	0.58
C ₅ ⁺	0.67
Total	100.00

3.7.3 VERTICAL-TYPE INDIRECT HEATED RETORT

In the IH retort, the heat of retorting is supplied by introducing an externally heated recycle gas stream, rather than by combustion within the retort as in the DH mode of operation. A schematic representation of the IH retorting system is shown in Figure 3.7-5.

3.7.3.1 Mechanical Description

The general layout of the vertical-type IH retort is shown in Figure 3.7-6. In comparison to the DH retorting system, there is no air blower, and a recycle gas heater is added to supply heat to the process, as opposed to burning residual carbon and recycle gas within the retort.

3.7.3.2 Process Description

Raw shale is introduced into the dual feed chutes, which are sealed with light oil. From these chutes, the raw shale is delivered into the retort chamber by two alternating rock pump pistons. In the retort chamber, the shale contacts hot recycle gas which is introduced at the top of the chamber. The products of kerogen pyrolysis descend to the bottom of the retort where they are withdrawn at two levels as oil and high-Btu gas. Processed shale is ejected to chutes at the top of the retort chamber, is quenched in the water seal, and is conveyed to disposal.

Produced gas is cooled to condense light oils. The gas is then split into recycle gas and net product gas. The recycle gas is heated in a fired heater and fed to the top of the retort. As in the DH retort, the product gas is scrubbed, treated to remove ammonia and sulfur compounds, and compressed before being used as fuel.

3.7.3.3 Product Characteristics

The estimated composition of the raw shale oil and high-Btu gas produced by the vertical-type IH retort is summarized in Tables 3.7-4 and 3.7-5.

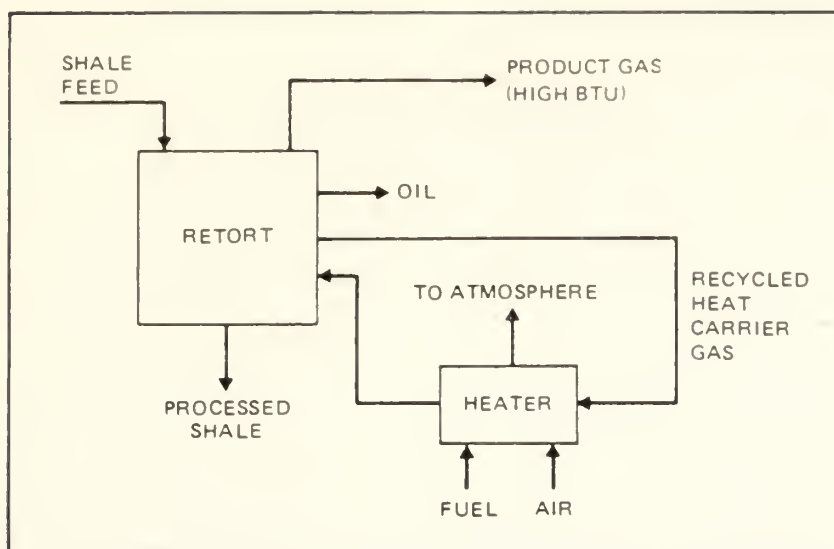


Figure 3.7-5 INDIRECT HEATED(IH) RETORTING SYSTEM

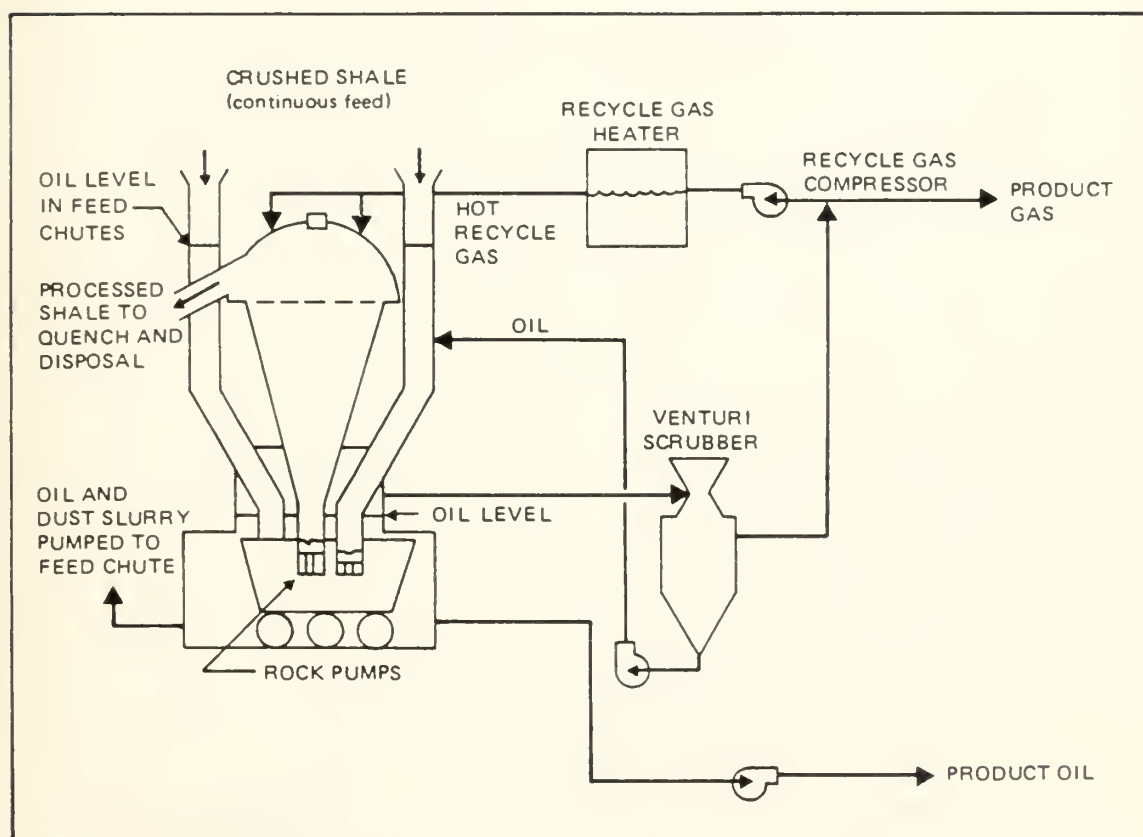


Figure 3.7-6 VERTICAL-TYPE IH RETORT

Table 3.7-4

ESTIMATED COMPOSITION OF RAW SHALE OIL:
VERTICAL-TYPE IH RETORT

Parameter	Value
Gravity, °API	20.2
Sulfur, wt %	0.55
Nitrogen, wt %	1.93
Distillation (ASTM D-1160)	
IBP, F	152
50, F	799
EP, F	1,100

Table 3.7-5

ESTIMATED COMPOSITION OF HIGH-BTU GAS:
VERTICAL-TYPE IH RETORT

Component	Vol % (Dry Basis)
H ₂	29.27
N ₂	—
CO	6.64
CO ₂	16.86
H ₂ S	3.23
NH ₃	(a)
C ₁	21.37
C ₂ 's	9.76
C ₃ 's	6.62
C ₄ 's	3.69
C ₅ ⁺	2.56
Total	100.00

(a) Ammonia concentration is 1,200 ppmV.

3.7.4 FINES-TYPE RETORTS

The fines-type retorting process uses an indirect heating mode with a solid heat carrier to produce kerogen oil from finely crushed oil shale.

3.7.4.1 Mechanical Description

The fines-type retort system is shown in Figure 3.7-7. This simplified schematic indicates the major functional items of equipment.

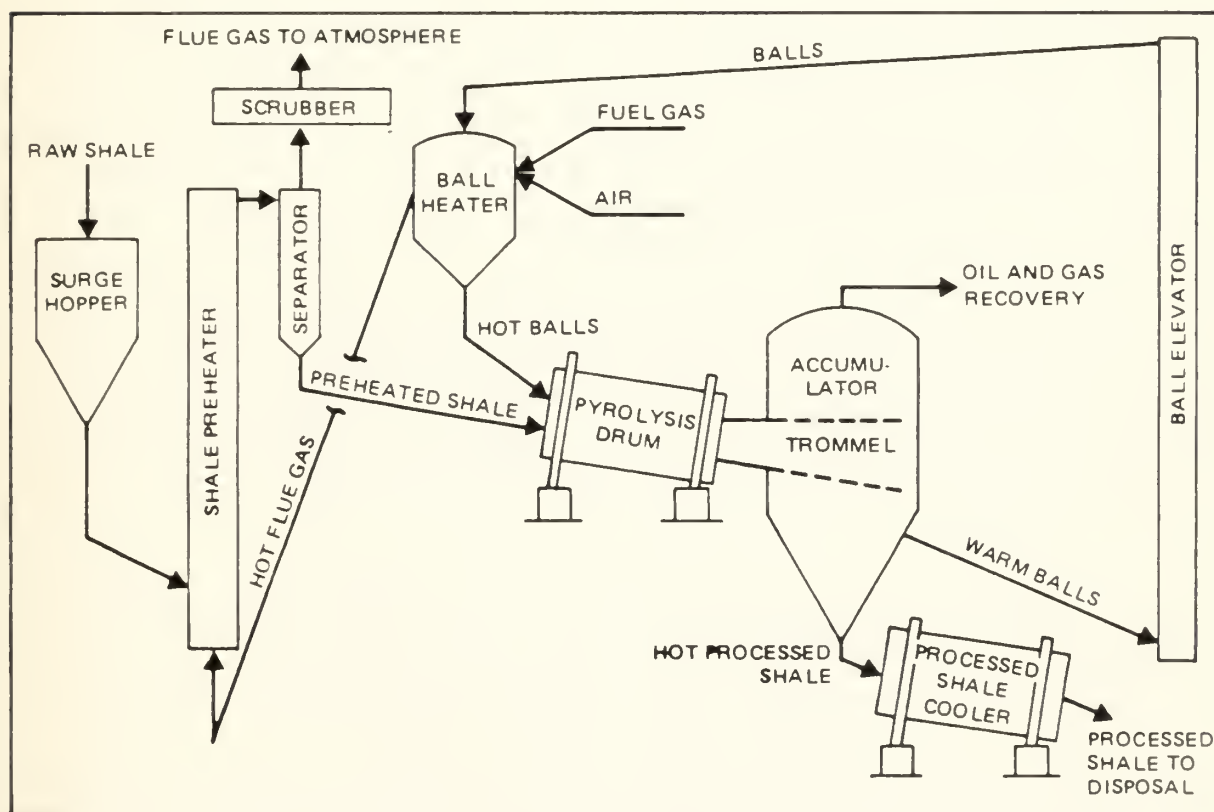


Figure 3.7-7 FINES-TYPE RETORTING SYSTEM

3.7.4.2 Process Description

Raw oil shale is first contacted with ball heater flue gas to preheat the solids before delivery into the pyrolysis drum.

Pyrolysis of the kerogen in the raw shale is accomplished in the pyrolysis drum by contacting the preheated shale with heated ceramic balls. In the pyrolysis drum, the crushed shale and ceramic balls are mixed to effect rapid heat transfer. The pyrolysis drum discharges directly into the accumulator.

Processed shale and balls from the drum are separated in a cylindrical trommel located within the accumulator. The warm balls pass from the accumulator to a ball elevator, while the processed shale discharges from the bottom of the accumulator to the processed shale cooler. Vaporized product shale oil and gas exit from the top of the accumulator.

Processed shale cooling is accomplished in two stages. In the first stage, the hot processed shale from the trommel is cooled in a rotating steam generator. In the second stage, the processed shale is cooled further by direct water quench in another rotating vessel. The cooled, moisturized shale is then delivered to processed shale disposal.

The ball elevator returns the balls to the ball heater, where they are heated to the required temperature by the combustion of fuel gas. The hot flue gases, after heating the balls, pass to the shale preheater.

Raw shale oil is condensed from the vapors leaving the retort section. The remaining gas is compressed and treated to remove ammonia and sulfur compounds before being used as fuel.

3.7.4.3 Product Characteristics

The estimated composition of the raw shale oil and high-Btu gas products of the fines-type retort are summarized in Tables 3.7-6 and 3.7-7.

Table 3.7-6

ESTIMATED COMPOSITION OF RAW SHALE OIL: FINES-TYPE RETORT

Parameter	Value
Gravity, °API	22
Sulfur, wt %	0.7
Nitrogen, wt %	1.9
Distillation, (ASTM D-1160)	
IBP, F	100
50, F	705
EP, F	1,100

Table 3.7-7

ESTIMATED COMPOSITION OF HIGH-BTU GAS: FINES-TYPE RETORT

Component	Vol % (Dry Basis)
H ₂	19.00
N ₂	—
CO	3.21
CO ₂	20.18
H ₂ S	3.84
NH ₃	1.02
C ₁	19.00
C ₂ 's	15.01
C ₃ 's	9.77
C ₄ 's	4.89
C ₅ ⁺	4.08
Total	100.00

3.7.5 POLLUTION CONTROL PROGRAM

The pollution control program proposed for the facility is discussed in Sections 4.2 and 5.2. These sections provide details on emission rates, pollution control plans, and effects on ambient air quality.

3.8 GAS AND OIL PROCESSING

The gas and oil products from the retorts will undergo treatment before being used as fuel, or transported from the site as a final product. This treatment is discussed below.

3.8.1 RAW SHALE OIL TREATMENT

Raw shale oil from the retorts (all types) will be treated to remove water and ash by demulsifier injection and two-stage desalting. No upgrading of the raw oil product is planned for any of the three project phases.

3.8.2 RETORT GAS TREATMENT

The gas produced in the retorts will contain significant concentrations of ammonia and sulfur compounds that must be removed before the gas can be used as fuel. The gas will be cleaned by passing sequentially through water wash towers and a sulfur recovery plant.

The water wash towers will remove essentially all of the ammonia and trace quantities of hydrogen sulfide. The sour water from the wash towers will be stripped of ammonia and hydrogen sulfide in a sour water stripper. The off gases from the sour water stripper will be incinerated in the utility plant boiler. The stripped water will be recycled to the water wash towers.

The sulfur recovery plant will be designed to reduce hydrogen sulfide concentrations below those required to meet EPA limitations on flue gas SO_2 concentrations. The recovered sulfur will be stockpiled for sale to available markets. The anticipated sulfur production is summarized in Table 3.8-1.

Table 3.8-1
SULFUR RECOVERY FROM PRODUCT GAS

Project Phase	No. of Sulfur Recovery Units	Sulfur Produced (TPSD)
I	2	20.6
II	5	75.6
III	8	139.2

3.8.3 POLLUTION CONTROL PROGRAM

Facilities will be provided in the pollution control program to minimize the emission of potential pollutants. Aspects of the program include:

- Sour water stripping for removal of ammonia and sulfur compounds in process wastewater
- Treatment and reuse of process wastewater
- Floating roofs and secondary seals, as required, on storage tanks
- Connection of various blowdowns to flares or to vapor recovery systems
- Connection of relief valves and turnaround purge vents to flares for vapor recovery systems in accordance with sound engineering practice
- Installation of pumps and compressors with mechanical seals

Details of the emission rates and the pollution control plans are discussed in Sections 4.2 and 4.4.

3.9 SOILS HANDLING

3.9.1 EXCAVATION AND DISPOSAL OF EXCESS MATERIAL

During the White River Shale Project, approximately 275 acres on Tracts Ua and Ub will be disturbed for placement of mine and surface facilities. This includes approximately 100 acres during Phase I, and 174 acres during Phases II and III. (Additional information can be found in Table 4.5-1.) Land disturbances and characteristics of materials, including plans for the ultimate disposition of the removed material, are described in Section 4, Planned Environmental Protection Procedures.

As much excavated material as possible will be used for construction activities. For instance, overburden from the Ub inclined entry will be used to grade the plant site and as fill, in part, for constructing project impoundments.

The proximity of Southam Canyon to most of the earth-moving construction activities in the process area and mine entries will allow unusable materials to be disposed of in the canyon along with processed shale. Disposal of excess materials in Southam Canyon will eliminate the need for numerous separate small landfills and will have no significant effect on processed shale disposal.

3.9.2 REGULATORY REQUIREMENTS

The Oil Shale Lease stipulates that excavated material and processed shale should be revegetated. Many additional requirements for overburden disposal and disturbed land reclamation appear in laws and regulations requiring that soils handling include measures for erosion control (thereby protecting water quality), slope stabilization, and revegetation.

3.9.3 TOPSOIL FOR REVEGETATION

In the current revegetation plan, topsoil will be obtained as needed from Southam Canyon. The specific amounts of topsoil required for this procedure will be determined during operation of the project. It may be found necessary to stockpile quantities of topsoil for later use; if so, temporary stockpiles will be placed on areas of the finished processed shale fill surface until they are needed. Slopes of these stockpiles will be stabilized to control erosion, but no revegetation efforts will be made.

3.10 PROCESSED SHALE AND FINES DISPOSAL

3.10.1 INTRODUCTION

After oil shale is processed in retorts and the kerogen is recovered, the retorted shale must be disposed of in an environmentally acceptable manner. Disposal of processed shale will be a major consideration in developing the oil shale lease tracts.

Disposal will be complicated by the present lack of large-scale commercial operations that could suggest proven procedures for handling the processed shale and placing it in a final location. In addition, only preliminary test data are available on the specific characteristics of the processed shale from Tracts Ua and Ub. Further analytical data on the characteristics of the shale will be required before design of the disposal area can be finalized.

In the most probable plan for processed shale disposal, Southam Canyon to the west of the processing area will be used as the disposal site for all project phases. Southam Canyon has the advantages of being on tract, of having sufficient volume to hold the anticipated amount of processed shale, and of having a relatively small drainage area. These characteristics suggest that disposal of processed shale in Southam Canyon will have a lesser overall environmental impact than disposal in alternative sites. (Alternatives are discussed in Section 7.10.)

This section discusses the characteristics of processed shale, the proposed disposal area, and the disposal plan for each phase of the project, including fill plan, water control and management, dust control, revegetation, and fines disposal.

3.10.2 CHARACTERISTICS OF PROCESS SHALE

The characteristics of processed shale are determined by three major factors: composition of the raw shale, the nature of the retorting process, and the retorting temperature. Shale processed by a vertical-type retort is a coarse material with a silty, gravel-like, gray-to-black appearance. Shale from a fines-type retort is a fine-grained, easily crumbled, silty black material.

The best data currently available on the characteristics of processed shale have been developed from Colorado shale processed by a Paraho vertical-type retort at Anvil Points. Since characteristics of processed shale from the White River Shale Project may differ somewhat from those described here, further analyses will be performed when site-specific shale becomes available in larger quantities.

3.10.2.1 Physical Properties

The physical properties described here and summarized in Table 3.10-1 are based on the Woodward-Clyde Consultants tests on Colorado material (Ref. 3-5).

On the basis of the gradation and plasticity tests, the sample shale falls into the silty gravels, gravel-sand-silt mixtures group, as classified by the Unified Soil Classification System. The apparent specific gravity (permeable voids filled with water) of 2.59 is on the order of values for concrete, sand, and gravel aggregate.

Compaction tests on the minus 1- $\frac{1}{2}$ inch fraction of the sample showed little gain in density with the addition of moisture up to optimum content. A significant increase in density occurred with increased compactive efforts (from 6,200 to 56,250 foot pounds per cubic foot). The low value is comparable to that achieved by tractor spreading or light rolling; the high value is the heaviest type of compaction normally obtainable and is used for high-loaded highway and airport subgrades. The processed shale took water readily and appeared to be porous. A temperature rise was noted after water was added, indicating that some hydration (and possibly some cementation) was taking place. Water retention capacities of processed shale are discussed further in Section 4.6.

Table 3.10-1

PHYSICAL PROPERTIES OF COLORADO PARAHO-PROCESSED SHALE^(a)

Gradation (ASTM D422)				
	Maximum particle size		2 in.	
	Clay (0.005 mm)		2%	
	Silt and clay (- No. 200 sieve)		22%	
	Sand (No. 200 to No. 4 sieves)		23%	
	Gravel (+ No. 4 sieve)		55%	
Plasticity (ASTM D423 and D424)				
	Liquid limit		—	
	Plasticity index		nonplastic	
Specific Gravity (ASTM D854)				
	Apparent (all sizes)		2.59 ^(b)	
Relative density ^(c) (ASTM D698)				
	Dense (100%)		89.4 lb/ft ^{3(d)}	
	Loose (0%)		71.5 lb/ft ^{3(d)}	
Compaction ^(c) (ASTM D698 and D1557)				
	Compactive Effort (ft-lb/ft ³)	Optimum Moisture (%)	Density (Maximum at Optimum Moisture) (lb/ft ³)	
Low	6,200	23.7	88.0	
Moderate	12,375	22.0	92.5	
High	56,250	22.0	98.0	
Permeability ^(c) (USBR Earth Manual, E-13)				
	Compactive Effort (ft-lb/ft ³)	Permeability at Loading (ft/yr)		
		50 psi	100 psi	200 psi
Low	6,200	15.5	5.5	1.7
Moderate	12,375	7.0	1.4	0.8
High	56,250	1.1	0.6	0.08

(a) Sample 1-B taken from Paraho semiworks plant at Anvil Points, Colorado.

(b) Average of two values.

(c) Minus 1½-inch fraction.

(d) Lower numbers have been reported by others on similar materials.

Source: Woodward-Clyde Consultants, Inc., Ref. 3-5.

Permeability of processed shale usually reflects its structure. To estimate surface runoff, seepage, and leachate potentials, the effects of compaction or loading on permeability must be known. Permeability measurements show that a relatively impervious material (permeability of less than 1 foot per year) can be produced from the Paraho-processed shale at the density achieved by heavy compaction or at the intermediate density with heavy loadings. The Ua and Ub shale is expected to exhibit somewhat lower permeability under similar compaction because of the presence of more fines.

3.10.2.2 Chemical Properties

The chemical composition of process shale and its relationship to the White River Shale Project is discussed in Section 4.6 and in the reports prepared by Woodward-Clyde Consultants (Ref. 3-5).

3.10.3 THE DISPOSAL AREA

Southam Canyon, just to the west of the processing area, is the preferred disposal area for shale processed in all phases of the White River Shale Project. The reasons for selecting Southam Canyon as a processed shale disposal area are:

- Its on-tract capacity, which is sufficient to contain the anticipated amounts of processed shale from the project
- Its geologic, hydrologic, and meteorologic characteristics, as summarized in Section 2
- Ecological considerations

One characteristic of Southam Canyon is its extremely irregular topography. While there is a general pattern of a depression within an east and west ridge system and a general downslope from south to north, many ridges and projections break up the entire canyon into a series of internal canyons. A section drawn through Tract Ua is shown in Figure 3.10-1.

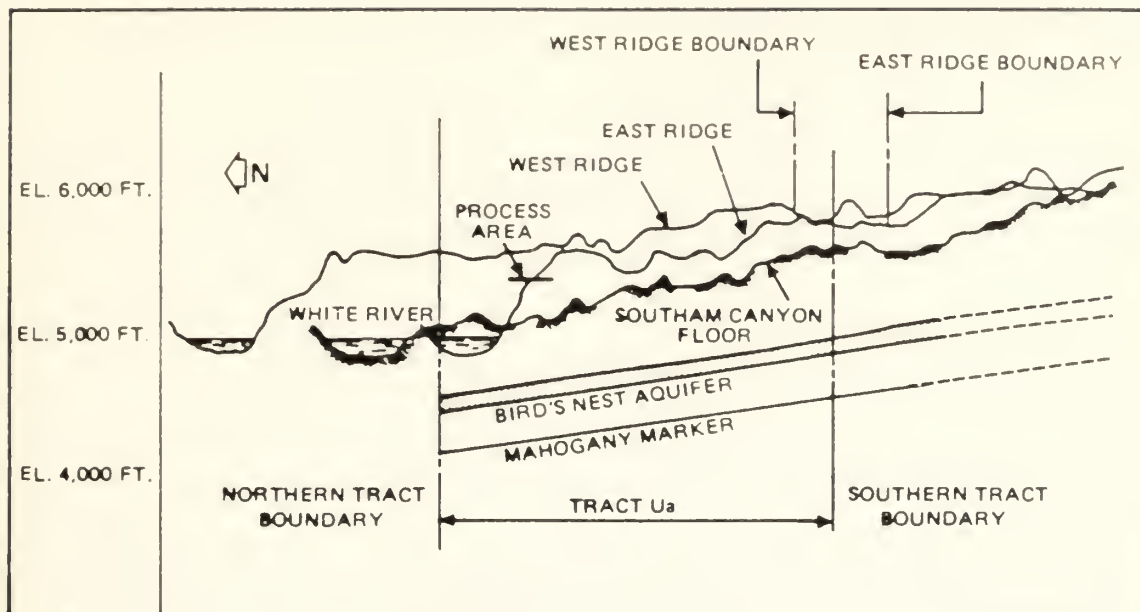


Figure 3.10-1 SECTION DRAWING OF TRACT Ua

During Phase I, this characteristic will be useful because the disposal area can be isolated in a side canyon. However, during Phases II and III, the rough topography of the canyon rather severely limits the variety of procedures that can be used for handling and placing the processed shale, as discussed in the alternatives presented in Section 7.10.

3.10.4 PHASE I DISPOSAL PLAN

Phase I operations will produce approximately 20,025 TPSD of processed shale. Discussed below is the plan for disposing of this processed shale in an environmentally acceptable manner.

3.10.4.1 Fill Plan

The processed shale from Phase I will be placed in a side canyon on the eastern ridge of Southam Canyon, as shown in Figure 3.10-2. Processed shale will be brought from the retorting area by conveyor southwestward to the haul road. The conveyor will deliver the processed shale to a truck loading bin, and from there, trucks will move it along the haul road to the disposal area.

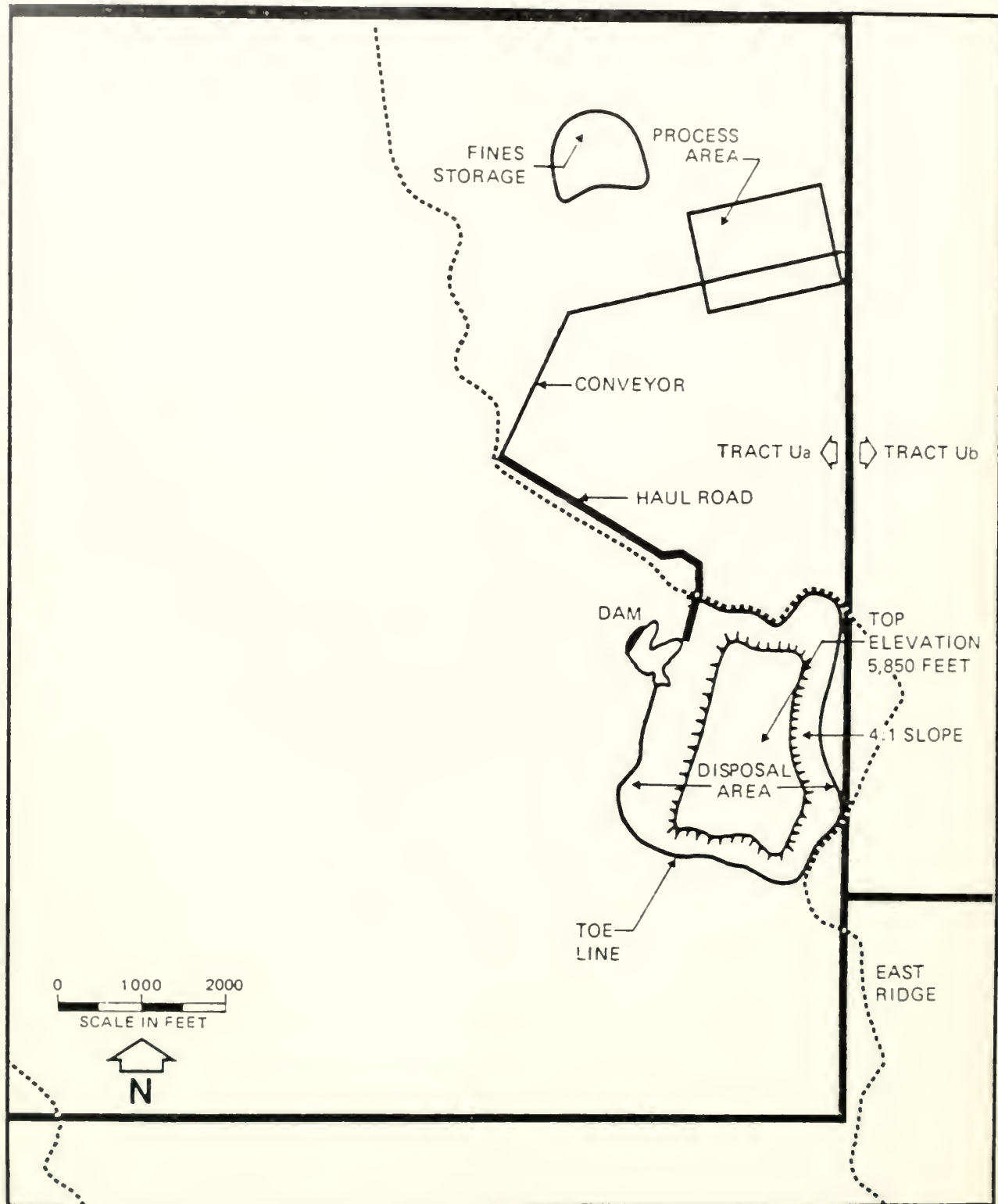


Figure 3.10-2 PROCESSED SHALE DISPOSAL, PHASE I

Filling will advance with about a 5 percent slope on the advancing edge to permit the bottom-dump trucks to descend and ascend the slope, dumping the material in layers and compacting it with their wheels. Bulldozers will complete the shaping of the pile. At completion, the top surface of the pile will be at an elevation of 5,850 feet, with a 4:1 (horizontal:vertical) slope.

If the mining operation never proceeds beyond Phase I, the processed shale will be left ready for revegetation in a small compact pile in this side canyon. If operations proceed into the commercial phases, various sections of this initial pile will provide a large-scale station (from 80 to 90 acres) for development of suitable revegetation procedures, will act as a valuable terminal for the covered processed shale conveyors that will come from the retorts in the commercial phase, and will serve as a staging area for the larger disposal operation.

3.10.4.2 Water Control and Management

Surface Runoff. A small dam will be constructed northwest of the Phase I processed shale pile to control runoff from the pile. The dam will include a cutoff and foundation treatment to control seepage. Its construction will maximize the use of local materials, and it will provide sufficient storage to contain runoff from the 100-year storm in a drainage area of approximately 300 acres. Small berms may be necessary in the northeast and southeast part of the disposal area to prevent contaminated water from entering the unprotected drainage basin to the east. A significant portion (approximately 90 percent) of the natural drainage of Southam Canyon will not be interrupted. Storm runoff that has not been in contact with the processed shale will continue to flow directly to the White River.

The dam will be abandoned when the project enters Phase II and will eventually be covered by future placement of processed shale. If the project does not continue into Phases II and III, the embankment will be raised 5 feet, and the dam catchment will contain any leachate and storm runoff. The resulting drainage impoundment will then function as an evaporation pond.

When the processed shale pile has reached final elevation, the surface will be shaped or sculptured in a pattern similar to that of contour farming, as shown in Figure 3.10-3. There is a dual purpose in this program: water runoff will be prevented or minimized, and water captured will be beneficial to plant growth both during and subsequent to the revegetation period. This minimizing of runoff from the surface will keep the volume trapped by the dam to a low level. A more detailed description of surface preparation and revegetation plans appears in Section 4.6.

Impounded runoff water from the processed shale pile will generally be poor in quality because of high salt content. The water will be unsuitable for either irrigation or leaching but will be very useful at the disposal site for supplemental dust control and compaction, as discussed more fully in Section 3.15.

Water Percolation. A review of available data (see Sections 2.2 and 2.3, and Ref. 3-1) suggests that the Bird's Nest Aquifer is unlikely to become contaminated with leachate from the processed shale materials. Downward percolation of leachate will be reduced by the compaction of the processed shale, first under the pressure of operating equipment, and then by the weight of the overlying material placed as the operation proceeds.

3.10.4.3 Dust Control

All of the operations involved in transporting processed shale from the retorts to the final placement point will generate dust. Dust control plans are detailed in Section 4 and include the following procedures:

- The processed shale will be moisturized as it leaves the retorts as a first step to control dust, to make the processed shale easier to compact, and to aid in cooling it.
- The entire length of the conveyor will be enclosed to prevent dust emission.
- At the loadout bins, a dust-suppression system using water mixed with a chemical wetting agent will minimize dust as the shale is discharged from the conveyor into the bin and from the bin into the hauling trucks.



Figure 3.10-3 CONTOURING FOR REVEGETATION PROGRAM

- Truck hauling routes will be continuously maintained using conventional road wetting and chemical stabilization techniques.
- As the processed shale is spread and compacted, water will be sprayed on it to stabilize the surface. A chemical wetting agent may be used if it proves effective in reducing water consumption or improving surface stability.

3.10.4.4 Revegetation

After the processed shale pile has reached final elevation, the surface will be contoured and plants will be placed in the depressions in earth-filled trenches (Ref. 3-6). This program is more fully described in Section 4.6. The top of the processed shale pile produced during Phase I, an area of approximately 80 to 90 acres, will serve essentially as a pilot revegetation station. The information and methods developed from ongoing research at Utah State University will be used to develop final plans for the commercial operation phase.

3.10.4.5 Fines Disposition

With the exception of fines produced during rescreening, all raw shale fines produced during Phase I will be stockpiled for future recovery. Fines produced during rescreening at the DH retort will be disposed of with the processed shale.

3.10.5 PHASE II AND III DISPOSAL PLAN

The commercial operation phases of the White River Shale Project will benefit significantly from lessons learned during Phase I. For this reason, the Phase I operation must be viewed as a means to examine closely the many complexities of the project and to make a series of judgments about the detailed engineering approaches to be used during the later phases. It is expected that new information about both processed shale and revegetation will emerge from Phase I and will have significant impact on the details of final design and operation. Therefore, it should be clearly understood that the plans for processed shale disposal described in the following paragraphs

are the best thinking available today, but they will be improved and augmented as information becomes available that will allow increased environmental effectiveness.

3.10.5.1 Fill Plan

In Phase II, processed shale is collected from the retort after cooling and transferred by conveyor to the disposal site in the eastern portion of Southam Canyon. A single conveyor with three transfer points and a tripper will carry processed shale to either of two movable conveyors each fitted with a tripper. Each movable conveyor, in turn, feeds a crawler-stacker that moves parallel to the conveyor and discharges processed shale in a linear pile. Bulldozers, scrappers, and compactors spread the pile and build up the disposal site in 50-foot lifts by working from the bottom up. Each of the two movable conveyors and its crawler-stacker will have sufficient capacity to handle the full design load. These movable conveyors will be relocated and extended during the operating phase, according to plan. Additionally, the approach conveyors will have to be sloped upward and/or raised to accommodate the greater height of the disposal pile during plant operation.

In Phase III, a second conveyor with its pair of movable conveyors and crawler-stackers will be extended into the central portion of Southam Canyon. This second conveyor will occupy the right-of-way of the Phase I processed shale conveyor.

Prior to the placement of processed shale in Southam Canyon, top soil over the disposal site is removed and stockpiled. As each section of the processed shale pile reaches its full predetermined height, this top soil is spread as top dressing for revegetation.

During Phase II, five retention dams are required to prevent runoff of water from the disposal area. One dam is located downstream of the disposal site.

This dam will retain all precipitation that will fall on the disposal area. Upstream of the disposal site, four small additional dams are required along the south boundary of the tract to prevent streams from penetrating the storage area. The retention dam constructed for Phase I will be buried during the course of the Phase II processed shale disposal operation.

3.10.5.2 Water Control and Management

Early during Phase II, a dam will be constructed near the mouth of Southam Canyon to control contaminated runoff from processed shale. This retention dam will be an embankment-type structure that maximizes the use of local materials, and it will include cutoff and foundation treatment necessary to control seepage. It will be designed to ensure safety of the structure and to prevent contaminants from entering the White River. The location of the dam is shown in Figure 3.10-4.

The water control plan promotes a reduction in drainage area by the placement of processed shale in Southam Canyon, thus reducing the quantity of contaminated runoff. The contouring and planting procedures will create many small catchment basins on top of the processed shale pile, and these will catch and retain precipitation.

As was true in Phase I, water that comes in contact with the processed shale will be contaminated by soluble salts. However, this water can be used for dust suppression at the disposal site. Information about the overall water balance of the White River Shale Project appears in Section 3.15.

Other features of water control and management will be patterned on the Phase I operation, adapted and altered as experience dictates. As designed, this system is adequate to meet all credible conditions.

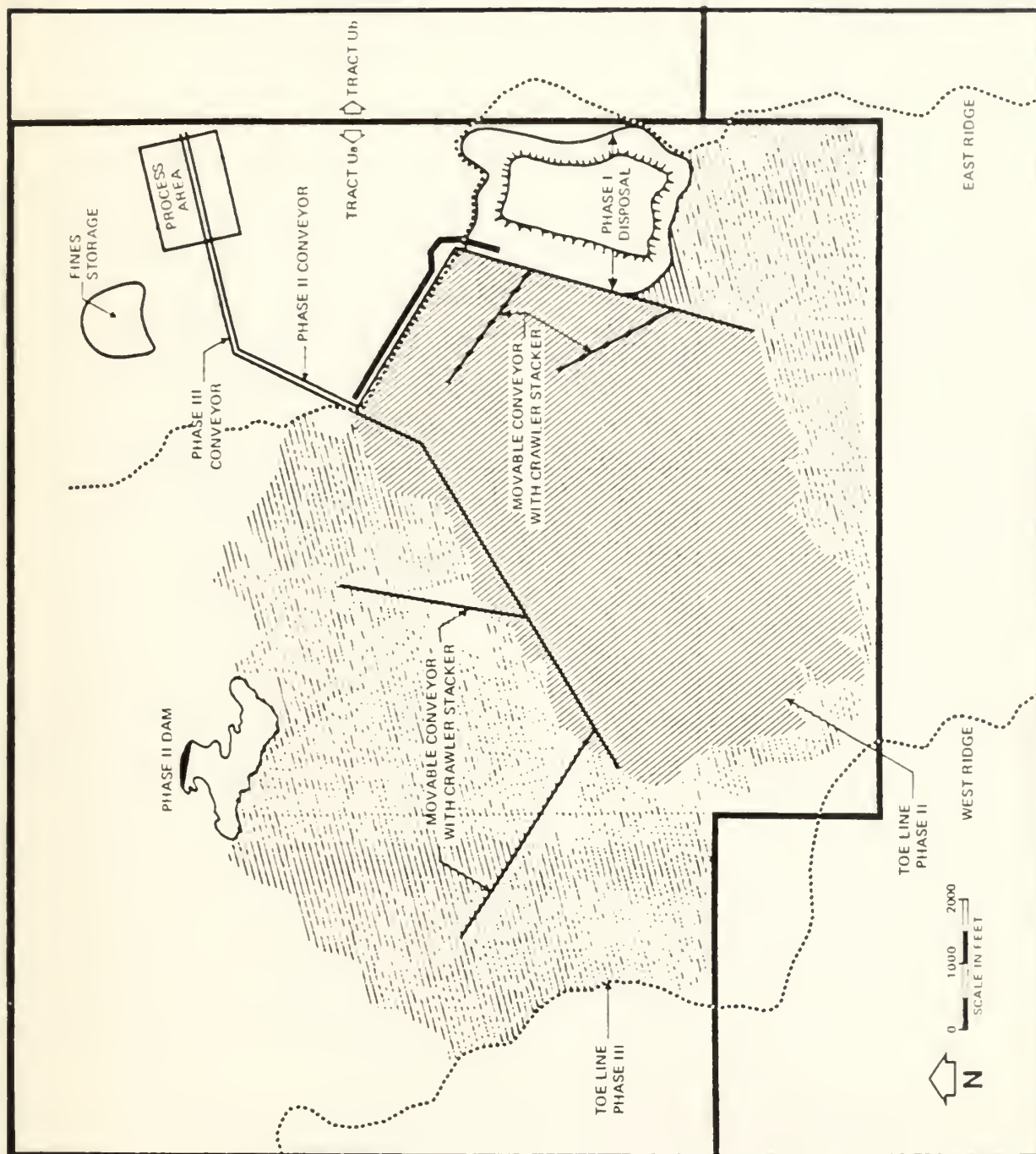


Figure 3.10-4 PROCESSED SHALE DISPOSAL, PHASES II AND III

3.10.5.3 Dust Control

Dust control techniques described for Phase I will be continued during Phases II and III. The same methods of control offer excellent promise of holding environmental contamination to acceptable levels.

3.10.5.4 Revegetation

At this time, the White River Shale Project can offer results from numerous field and greenhouse studies (Refs. 3-7, 3-8) about how the revegetation problem could finally be solved. Additional revegetation data are forthcoming from continuing research at Utah State University. However, the basic approach of arranging a sculptured and contoured surface that will result in maximum water retention appears to be a key element of the revegetation program. It is likely that experience gained during Phase I and in early commercial operation will permit a revegetation program to proceed in an orderly and successful fashion throughout the life of the project.

3.10.5.5 Fines Disposition

Fines produced during Phase I operations will be stockpiled to the northwest of the plant. These stockpiled fines, together with additional fines produced during Phases II and III, will be processed in fines-type retorts.

3.11 SOLID WASTE DISPOSAL

This section briefly describes solid waste sources and types, their collection, and their disposal for various phases of the White River Shale Project. Overburden disposal and processed shale disposal are discussed in Sections 3.9 and 3.10, respectively. Figure 3.11-1 shows the overall scheme for solid waste disposal during the major project phases.

3.11.1 SOLID WASTE SOURCES AND TYPES

The bulk of solid waste from construction and operation of the project will be inert construction debris, totaling about 45,000 tons. Lesser quantities of other waste will also be produced.

At full commercial production (Phase III) there will be approximately 700 tons per year of waste fire bricks and fines-type heat carriers. Miscellaneous wastes consisting of water, wastewater sludge, and general plant trash and garbage will also be produced throughout all project phases. Proportionately less waste will be generated during Phase II than during Phase III.

3.11.2 WASTE COLLECTION

During all construction phases, waste construction materials will be deposited in large bulk containers and dumpster bins strategically located throughout construction areas. Smaller container bins (with hinged covers) will also be used to collect general trash and employee garbage. Waste oils, rags, and other oily or chemically contaminated material will be segregated and collected in safe, fireproof containers. Hazardous wastes will require special collection, handling, and disposal procedures.

Miscellaneous waste will be collected and handled in the same way in all phases. Trash and garbage will be deposited in covered bins. Skimmed

oils from wastewater facilities will be pumped into the slop oil tanks and later recovered. Wastewater treatment sludge will be digested and stored in drying beds for later use in soil conditioning; it will also be used to moisturize processed shale.

Slurried dust from the various dust scrubber systems will be injected into the processed shale moisturizers. (Although it would be possible to reclaim the slurried dust and feed it to the fines-type retort, this material is extremely fine, and most of it would blow right through the retort, ending up once again in the scrubber system.) Slurry wastes, which are mixed with the processed shale, will be transported by conveyor to the processed shale disposal site. Amorphous elemental sulfur from the sulfur recovery unit will be transported to a separate storage pile.

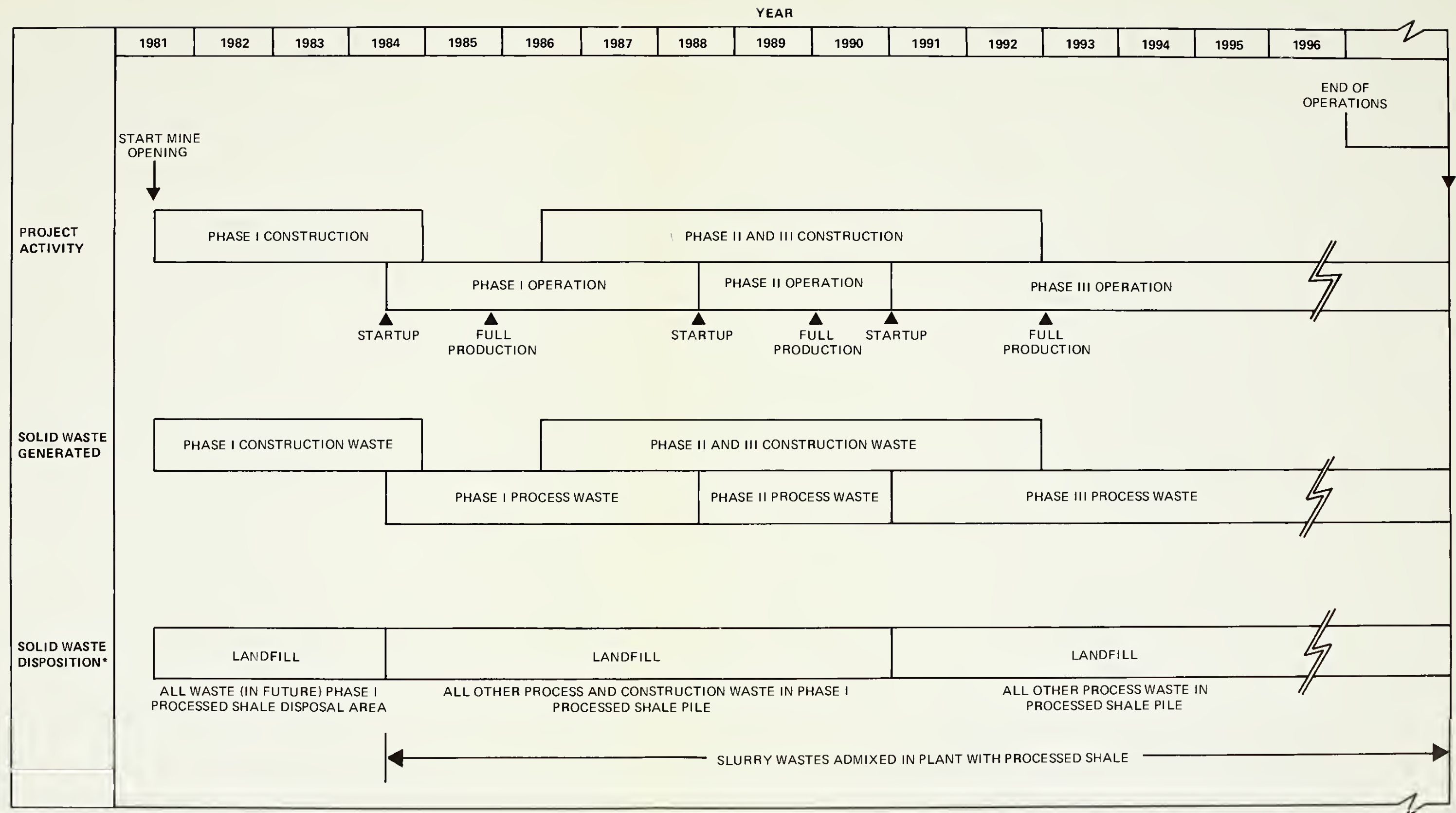
During construction and operation phases, all non-hazardous solid waste will be transported by truck and deposited in the processed shale disposal area in Southam Canyon. Collection frequency and equipment will be appropriate for the quantities and types of waste being generated.

3.11.3 WASTE DISPOSAL

All of the non-hazardous solid waste will be landfilled in the processed shale disposal area, either mixed directly with processed shale at the plant or separately disposed of in a landfill and covered with processed shale later.

Non-hazardous solid waste landfill activities will be confined to specific sites to facilitate ultimate coverage by large quantity of processed shale. Land-fill sites will be developed sequentially, but only one site will be active at any time. Hazardous wastes will be confined to appropriately designed disposal sites.

During Phase I construction, the landfill site will be located in one corner of the processed shale disposal area (see Figure 3.10-3). Overburden



* Hazardous wastes will be disposed of in accordance with the Resource Conservation and Recovery Act.

Figure 3.11-1 SOLID WASTE DISPOSAL SCHEMATIC

from construction may be used for temporary cover material. (Processed shale will not be available at that time.) Waste will be discharged at a small working face, using an area landfill method, and will be spread, compacted, and covered.

During early Phase I operation, non-hazardous solid waste will continue to be deposited in this landfill until the deposits of processed shale reach the site. A new site located in the shale disposal area will be used for solid waste disposal throughout the remaining Phase I operation period.

As Phase II construction begins, a new non-hazardous solid waste landfill site will be located in the western side of Southam Canyon. During Phase II operation, the processed shale embankment will eventually cover this solid waste landfill. As the processed shale pile progresses, new solid waste disposal sites will be created, as needed, and the solid waste landfills will become layered in the processed shale.

The same landfill procedures (spread, compact, and cover) will be used throughout Phases II and III. Revegetation of completed sections will be carried out in conjunction with the processed shale revegetation activities.

Section 4.3 describes the solid waste landfill procedures in more detail.

3.12 UTILITIES AND SUPPORT FACILITIES

Utilities and supporting facilities will be required at various levels throughout the development of the project. The facilities and requirements include electric power, water for steam generation and cooling service, water for processed shale wetting, and communications services.

Fuel required for process heating, steam generation, electric power generation, and miscellaneous uses will be provided by burning high- and low-Btu by-product gases (supplemented by other fuels as necessary) or alternatively by importing electric power.

Communication facilities will include a complete internal telephone system, a tie-in to outside public telephone facilities, and radio communications gear, as expedient.

The general requirements and plans for these utilities and services are described in the following subsections.

3.12.1 ELECTRIC POWER

The electric power systems of each phase of the project are described in the following paragraphs. From the start of Phase I operation through Phase III, there are varying degrees of overlap in the system descriptions.

A breakdown of the normal operating power requirements is given in Table 3.12-1. These requirements and the estimated in-plant power generation are listed in Table 3.12-2.

3.12.1.1 Phase I Power

Electric power will be purchased from the Moon Lake Electric Association. Power will be delivered to the plant by a new openwire transmission line

Table 3.12-1

BREAKDOWN OF ELECTRIC POWER DEMAND
(MW)

Area/System	Normal Power Demand		
	Phase I	Phase II	Phase III
Mining	13.6	38	63
Conveying and Secondary Crushing	4.5	18	32
Processing	17.7	71	146
Steam and Power Plant and Air Compression	0.6	6	11
Water Systems (Raw, Cooling, and Service)	1.3	10	18
Miscellaneous Offsites	1.3	8	12
Total	39	151	282

Table 3.12-2

ESTIMATED ELECTRIC POWER DEMANDS AND GENERATION
(MW)

Project Phase	Normal Power Demand	Normal Power Generated	Power Exported
Phase I	39	0	0
Phase II	151	191	40
Phase III	282	389	107

approximately 9 miles long from a location near Bonanza, Utah to a high-voltage transformer substation near the mine service building. Power will be supplied at 138 or 69 kV and will be distributed at reduced voltage to load centers in the plant. The transmission line should have sufficient capacity to handle the Phase III export power of 130 MW.

Full-voltage nonsimultaneous linestarting of the large motor drivers for several compressors in the retort areas may not be possible. This will depend on the capacity of the Moon Lake power system at the time of plant startup. Reduced-voltage starting, small auxiliary starting (pony) motors, and/or smaller compressors may be required.

Maximum construction power, estimated at 7 MW in 1981, 8 MW in 1982, and 12 MW in the latter part of 1983 can be supplied from onsite temporary power generators or from the new 138 or 69 kV power line.

3.12.1.2 Phase II and III Power

Two 110 MW generators will be installed in the power plant for Phase II and two more for Phase III. The surplus power generated will be exported normally via the 138 or 69 kV transmission line installed for Phase I. The transmission line will also supply power to the plant from Moon Lake during planned or forced generator outages.

Construction power for Phases II and III is estimated at 12 MW maximum. About 8 MW can be supplied from the high-voltage substation installed for Phase I. The remainder will be supplied from temporary onsite power generators.

3.12.2 STEAM REQUIREMENTS (PHASE III)

Steam will be required for heating, mining (including primary crushing), secondary crushing, and processing.

In order to maximize energy efficiency, all available by-product gases will be used to generate steam. Surplus steam (in excess of basic process

and utility requirements) will be used to power turbines for certain large mechanical drivers (compressors, blowers, pumps, etc.) and to generate electricity for both captive use and export to the outside power grid.

3.12.2.1 Process and Offsite Use

Steam will be required for process equipment drives, and even more for electric power in the mine and in feed shale crushing and conveying, process plant, and offsite uses. The offsite uses will include tank heating, processed shale conveying, lighting, heating, and ventilation. In the commercial plant design, electric power will be produced by generating steam in boilers, expanding it through turbines, and exhausting it at vacuum condition into water-cooled condensers.

Steam generated for these turbine-drive generators will be delivered at 1,500 psig and 900F. Under these conditions, and with the generator turbines exhausting at about 1 psia, approximately 2,950,000 pounds per hour of steam will be required. The turbines will be of extraction type, and some steam will be withdrawn at 600 psig to supply the 600 psig process requirements.

3.12.2.2 Equipment Drivers

Mining, crushing, and conveying operations will require enough electric power to produce 121,000 brake horsepower output from the various drive motors in those systems. Process drivers, cooling tower fans and water-circulating pumps, and offsite drivers will have a shaft brake horsepower output of 239,300; thus the total shaft horsepower required will be 360,300. Some 31,300 horsepower of this total will be carried by steam turbines, leaving a net load of 329,000 horsepower to be supplied by electric motors. This load, plus some power plant accessory loads, will require the generation of 282 MW of electric power.

A considerable amount of low-Btu gas will be fired in boilers to generate steam for driving turbine alternators and supplying the process requirements. Some steam will be required to drive boiler feedwater pumps.

3.12.3 BOILER PLANT (PHASE III)

3.12.3.1 Boilers

The power plant will have four industrial-type steam boilers of 950,000 pounds per hour generating capacity each, with full reheat capability. These boilers will be designed for 1,800 psig maximum pressure and will deliver their steam at the superheated outlets at 1,500 psig and 900F.

3.12.3.2 Feedwater Pumps

Feedwater pumps for the main power boilers are included in the plant design:

- 2 booster pumps, plus two spares, two with steam turbine drive, two with motor drive, capacity 4,500 gpm, 200 psi differential
- 2 high-pressure pumps, plus two spares, two with steam turbine drive, two with motor drive, capacity 4,500 gpm, 1,600 psig differential

3.12.3.3 Feedwater Treating

A boiler feedwater deaerator will be required. The feed to this deaerator will be condensate, makeup boiler feedwater, and 50 psig steam. Operating conditions will be 14 psig and 246F. A feedwater makeup treating system of full demineralization type for 300 gpm will be required.

3.12.3.4 Boiler Blowdown

Boiler blowdown for power plant boilers will include continuous skimming of the steam drums at the water-steam interface and intermittent blowdown of the lower drums.

3.12.4 FUEL REQUIREMENTS (PHASE III)

Excess low-Btu fuel gas product will be used as boiler fuel. This fuel has a total heating value of 4,550 million Btu's per hour. Excess high-Btu fuel gas product and supplemental fuel will also be fired at a rate that will provide an additional heat release of 1,130 million Btu's per hour.

3.12.5 COOLING TOWER (PHASE III)

The cooling water tower will have a capacity of 410,000 gpm with water inlet temperature at 100F, outlet at 75F, summer dry bulb 90F, wet bulb 65F, and approach to wet bulb 10F.

3.12.6 COOLING WATER PUMPS (PHASE III)

Cooling water pumps will comprise 14 vertical-shaft centrifugals of 30,000 gpm capacity with 80 psi differential pressure. Eight of these pumps will have 2,000 hp motor drivers, and six will have 2,000 hp steam turbine drivers. The cooling tower will be approximately 300 feet away from the process area.

3.12.7 AIR SYSTEMS (PHASE III)

Air for plant utility use will be supplied by two 2,000 scfm reciprocating air compressor dryer sets with 125 psig discharge pressure. One machine will have electric motor drive, and one will have steam turbine drive.

Instrument air will be provided by three 1,000 scfm compressor dryer sets. Tie-in stations for emergency use of the utility air system will be required.

3.12.8 INTERCONNECTING LINES

The retorting sections will have large gas and air piping that is part of the process system and does not constitute interconnecting lines. The

vertical-type retort section will have product gas headers running from the retort section mid-area to the power plant by way of a gas treating plant.

Product oil from the retorts will be pumped to the storage tanks. Cooling water will be circulated from the cooling tower to the processing units and the power plant. Other interconnecting lines are primarily for utilities (steam, condensate, water, air, and supplement fuel).

The lines will be predominantly overhead, heat traced, and insulated where appropriate.

3.12.9 PRODUCT LOADING (PHASE III)

The raw shale oil will be sent via cross-country pipeline to Borger, Texas.

Solid sulfur by-product will be produced at a rate of 139 TPSD in the proposed commercial plant, and will be stockpiled or trucked to a suitable market. Trucks will be loaded by front-end loaders moving the sulfur from outdoor storage on concrete slabs with curbs to serve as solidification pans.

3.12.10 CHEMICAL HANDLING

Chemicals required for water treating and other purposes will be stored indoors in metal drums.

3.13 ANCILLARY FACILITIES AND MAINTENANCE

This section describes those ancillary facilities that are essential to the continuing safe and orderly conduct of the project. All phases of the shale oil project will require some facilities described in this section. These will be provided when necessary to support activities within each phase.

3.13.1 RELIEF AND BLOWDOWN

A relief system is provided to vent the net vapors from the retorts to the flare stacks (gas incinerators) in the event of a power outage or trip on the net product gas compressors. Each flare system includes a liquid knockout drum at the flare, a water seal at the bottom of the flare, and provisions for injecting steam at the flare tip for smokeless burning of the normal relief flow to the flare. One complete flare system will be provided in each phase.

Pressure vessels requiring valves to protect them from overpressure will have pressure relief valves that discharge to the same relief system described above.

One pump and one tank are provided for slop oil recovery.

The flare stacks will serve as safety relief for the disposal of excess gas produced in the process area during atypical operation.

3.13.2 PLANT DRAINAGE

3.13.2.1 Oily Water Sewers

In all phases, the oily water sewer system will collect all contaminated surface drainage from the process areas, as well as oil-bearing waste streams from the process areas. This system will follow standard refinery

practices and will be sealed or trapped and vented to prevent travel of hydrocarbon fumes from one process area to another. All vents will be routed to discharge in safe locations.

The oily water sewer system will discharge to a receiving tank in the waste treatment plant. This system will be a buried gravity sewer.

Plant paving will be designed to prevent oily spills from draining across the surface to another plant area.

3.13.2.2 Sanitary Sewers

Sanitary sewers will collect sanitary wastes from all facilities in the main plant area. These wastes will be segregated from other wastes and routed separately to the treating facilities.

The processed shale disposal facilities will have their own collection system and will not be connected to the plant sanitary sewer system. This system will be the normal, buried gravity sewer system.

3.13.2.3 Storm Sewers

Storm sewers in the plant area will consist primarily of an open-ditch system. Culverts will be built at road crossings, and access will be provided across ditches, as required. In congested areas, underground sewers will be installed but will be run to open ditches. Plant drainage will be arranged so that only nonoily surface waters will be drained into this system. Roof drains and parking lot drainage will run into this system.

Basins or small dams will contain tank spillage and drainage water from the tankage area. After each storm, the drainage water retained by the structures will be released to flow to the wastewater holding basin.

3.13.3 TANKAGE

In general, it is planned to locate shale oil storage tanks on suitable base pads, which will be made by leveling small areas of the rocky surface of the site. The individual pads will be located so that overflows or leaks will drain away into an adjacent catchment basin that will provide a catchment volume adequate for containing the volume of the particular tank or tanks being protected.

The service tankage provided in Phase I will be retained for Phases II and III, as indicated in Table 3.13-1.

Table 3.13-1
TANKAGE SUMMARY^(a)

Service	Capacity (Bbl)	Diameter (ft)	Height (ft)	Roof Type	Heated
Fuel Oil	2,100	25	24	Floating	Yes
Diesel Oil	505	15	16	Floating	No
Raw Shale Oil	56,000	100	40	Floating	Yes
Raw Shale Oil ^(b)	250,000	200	48	Floating	Yes
Slop Oil	505	15	16	Floating	Yes
Raw Water/ Firewater ^(c)	56,000	100	40	Floating	Yes
Sour Water Phase I	12,000	50	35	Cone	Yes
Phase II	55,000	100	40	Floating	Yes
Propane ^(d)	135	6	24	N/A	No

(a) Tanks located in areas other than the main tank farm are not listed.

(b) Two added in Phase II, and one added in Phase III.

(c) In post-Phase I operation, will be in fuel oil service.

(d) Horizontal pressure vessel measuring 6 feet in diameter by 24 feet tangent to tangent.

3.13.4 WATER STORAGE PONDS

3.13.4.1 Freshwater Storage Pond

The on-tract storage pond constructed for Phase II ("E" on Figure 3.4-2) will provide a water reserve to maintain a constant supply of water during an outage of the reservoir pumping station or pipeline. Its 210 acre-foot volume will provide 3 days of water supply for the maximum capacity of both the plant and the processed shale disposal area. The dam for this pond will be built to conform to applicable engineering standards.

3.13.4.2 Wastewater and Storm Runoff Holding Basin

An embankment-type dam will be constructed downstream from the process area early in Phase I, as shown in Figure 3.4-2. This dam will also be built to conform to applicable engineering specifications.

Its storage exceeds the 100 year storm runoff volume from all tributaries during the Phase I stage of the project. Wastewater, storm runoff, and minor oil contaminants will be collected in this basin.

3.13.5 FIRE PREVENTION AND CONTROL PLAN

The level of fire protection proposed for this project is equivalent to what is defined as highly protected risk by the insurance industry. Protection conforming to this definition will consist of automatic extinguishing and detection systems, engineering safeguards, and fire-fighting water supplies. The protection will be consistent with the needs of all design-basis fires.

The major plant structures and work areas and the type of protection to be provided are as follows:

- Administration Building. Because of the type of function, occupancy, and records storage, fire hazard is considered "light to ordinary." An automatic sprinkler system and installation of fire extinguishers are proposed.

- Cafeteria. Fire hazard is "light," requiring only fire extinguishers.
- Laboratory. The use of solvents and chemicals and their storage and handling increase the hazard category to "ordinary" (Group 2). Automatic sprinklers are proposed.
- Control Room. Fire hazard in the control room is deemed "light." Special protection is proposed only in the cable spreading area, where engineering safeguards may be used. In addition, installation of fire extinguishers is proposed.
- Maintenance Shops. Work in the shop areas is considered "ordinary" (Group 2). Hazards arise from painting, carpentry, and machine shop work. Automatic sprinkler protection will be provided throughout, along with fire extinguishers, standpipes, and small hose lines.
- Warehouse. General storage of supplies categorizes this facility as "ordinary" (Group 3). As such, automatic sprinkler protection, standpipes, hoses, and fire extinguishers are proposed.
- Electric Power Generator Building. The hazard category for this facility is classified as "ordinary." However, certain systems and equipment may be considered "extra hazard," depending on use. In this category are generator lube oil systems, which can be protected with water spray, CO₂, or engineering safeguards such as a fire enclosure. Hydrogen-cooled equipment is also in this category. An automatic CO₂ fire extinguishing system is proposed if a hydrogen gas hazard exists. In addition, standpipes, hoses, and fire extinguishers are proposed.

Major processing hazards and protection measures are as follows:

- Shale Pile. Storage of mined shale of the anticipated quality is not expected to be a significant hazard. It is judged to be less than that of coal. Accordingly, storage will be in a segregated area with no special protection.
- Crushing Operations. There is a potential fire hazard associated with this operation. Normal engineering safeguards, such as wet-down and vacuum collection of dust, should be effective for the potential hazard.

- Retorting and Process. The fire hazard in the processing area is relatively severe and will require engineering safeguards, automatic fire detection systems, automatic fire extinguishing systems, fireproofing, monitors, and other standard petroleum industry techniques for fire protection.
- Tank Storage. Storage of all hydrocarbons is hazardous. Protection will be afforded by spacing, spill control, cooling, and fire extinguishing systems.
- Processed Shale. Handling cooled processed shale is not expected to be a significant fire hazard. The wetted shale will be transported to the disposal area and compacted without any post-cooling provisions for fire protection.
- By-Product Hazards. The sulfur by-product presents some fire hazard and will be stored in a segregated area. No special fire protection will be provided except for engineering safeguards of isolation and containment.
- Conveyor Ways. These should not pose a serious hazard.

3.13.6 MEDICAL FACILITIES

Medical facilities will include first aid facilities, a clinic, and ambulances.

First aid facilities will be furnished at appropriate locations in the process plant, power plant, maintenance areas, mine, and crushing areas.

A clinic will be provided with examination rooms and equipment (including two hospital-type rooms) and office and laboratory space for a physician and two nurses.

A garage facility will be provided at the plant for two ambulances. The distance to the nearest extensive hospital facilities (in Vernal) is about 50 miles.

3.13.7 BUILDINGS AND PARKING

Buildings for the process plant and their square footage are listed in Table 3.13-2. The construction of these buildings will be fireproof. The administration building, control house, change house, and laboratory will be of modern design with full air conditioning, heating, and ventilating equipment.

The shop building, boiler house and power plant, secondary crushing house, firehouse, and any other buildings can be of steel frame industrial type construction with metal or plastic sheet sheathing.

Parking facilities for vehicles of staff and visitors will be provided by grading a suitable area.

3.13.8 MOBILE EQUIPMENT

Approximately 27 units of mobile equipment will be required for the re-torting and processing plant.

Table 3.13-2

BUILDING REQUIREMENTS

Service	Area (ft ²)	Remarks
Administration	30,000	Two-story, steel and concrete
Cafeteria	15,000	
Change House	13,125	Steel and concrete
Main Shop and Warehouse	70,000	Steel and transite
Firehouse and Garage	15,000	Steel and transite
Secondary Crushing House	42,000	Steel and transite
Control Houses with Offices	32,250	Steel and concrete
Main Boiler and Electric Plant	180,000	Steel and transite
Laboratory	11,000	Steel and concrete
Gate House	300	Steel and transite
General Building	20,000	Steel and transite

3.14 WATER SUPPLY FACILITIES

3.14.1 WATER SUPPLY DEVELOPMENT PROGRAM

Supplying water for the development of oil shale in eastern Utah, as well as for other essential uses and purposes, is a matter of obvious importance. This subject was studied and reported on by Bingham Engineering of Bountiful, Utah in 1976 (Ref. 3-9). The water supply development program described below is based on their report.

3.14.1.1 White River Dam

Alternative sources of water considered are discussed in Section 7.14. The preferred alternative is a dam and reservoir to be constructed by the state of Utah on the White River, with related pumping facilities to deliver water to Tracts Ua and Ub. The project would be a multipurpose development that would provide a firm water supply for oil shale processing on each tract and that would have a capacity sufficient to furnish water for additional oil shale development in the area. Releases would be made from the reservoir to develop and maintain a stream fishery below the dam and to provide irrigation water for up to 14,000 acres of land near the mouth of the White River. This land is primarily Ute Indian tribal land claiming water rights under the Winters Doctrine.

3.14.1.2 General Description of the Basin

The White River rises in the White River Plateau in western Colorado and flows west to its confluence with the Green River at Ouray, Utah, about 26 miles south of Vernal, Utah. The White River Plateau is a relatively flat area at elevations of from 10,000 to 11,500 feet. The average annual precipitation in this area is more than 30 inches. The river receives most of its water supply from this area and then runs westward to the desert rangeland of western Colorado and eastern Utah.

The Utah portion of the White River Basin is mostly desert rangeland with elevations near 5,000 feet. This area is semiarid, characterized by low

relative humidity and a wide range of daily temperatures. Mean monthly temperatures vary from near 20F in January to 75F in July, with daily maximums in the 90's. The mean annual temperature is 48F.

Precipitation in the Utah portion of the White River Basin averages close to 7 inches in the lower elevations and close to 12 inches in the higher elevations. The May to September pan evaporation is approximately 37 inches.

3.14.1.3 White River Hydrology

Records are available over the last 50 years for mean daily, monthly, and annual discharges of the White River near Watson, where a gauging station is located near the crossing of Utah State Road No. 45. These records indicate that most of the foreseeable diversion requirements can be met on an annual basis provided there is adequate storage in a reservoir to permit regulation of seasonal and daily variations in the river discharge.

A flow chart of the White River showing the streamflow and present depletions is shown in Figure 3.14-1. The major use of water is for irrigation, and nearly 95 percent of the irrigated land is devoted to the production of hay and irrigated pasture. About 41,000 acre-feet of water are presently used in Colorado. About 7,700 acre-feet of water are used in Utah for lands owned primarily by the Ute Indian tribe.

3.14.1.4 Water Rights

The Colorado River Compact of 1922 divides the waters of the Colorado River into a Lower Division and an Upper Division, with the dividing point at Lees Ferry, Arizona. The compact intended to give the Upper Division half of the river flow at Lees Ferry. However, the Lower Division (Arizona, Nevada, and California) is guaranteed 7.5 million acre-feet annually.

Because the historic flows since 1922 are less than 15 million acre-feet, the Upper Division entitlement is something less than 7.5 million, depending on

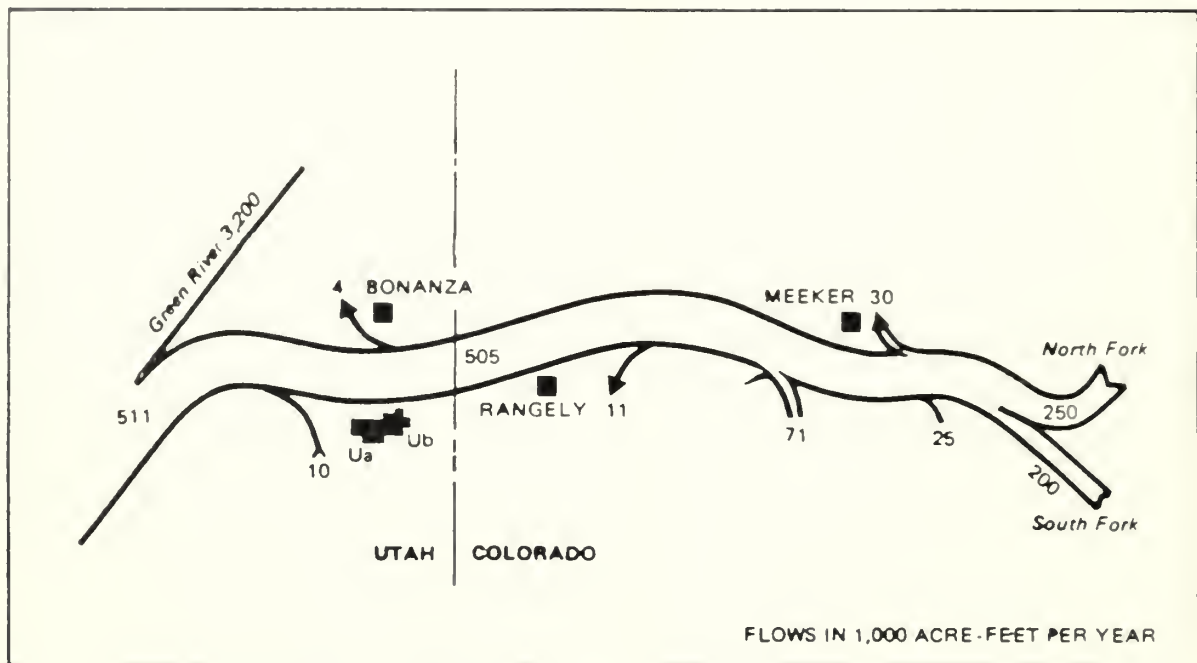


Figure 3.14-1 WHITE RIVER FLOW

the water supply. The Bureau of Reclamation now estimates the Upper Basin entitlement at 5.8 million acre-feet annually.

The upper Colorado River Basin Compact of 1948 divides the waters of the Upper Basin on a percentage basis. Utah is entitled to 23 percent and Colorado is entitled to 51.75 of the Upper Division allotment. The remaining percentage goes to Wyoming and New Mexico.

The Upper Basin Compact does not apportion the waters of the White River between Colorado and Utah, nor does the compact appear to offer any procedure to effect an apportionment. Therefore, Colorado and Utah could approve applications from the White River as long as they do not exceed the ceiling provided for in the compact. Discussions between Utah and Colorado with respect to a compact for using water from the White River have not resulted in agreement over water allocations.

It appears that under the principles that govern the allocation of interstate streams, Utah could assert that it is entitled to an equitable share of the flow of the White River (Hinderlider vs La Plata River and Cherry Creek Ditch Co., Ref. 3-10). Under this concept, each state through which an interstate river flows is entitled to an equitable share of the water from its source.

Neither Colorado nor Utah presently consumes its full entitlement of water under the Upper Colorado River Basin Compact. It is estimated that Utah has 197,000 acre-feet of uncommitted water and that Colorado has approximately 167,000 acre-feet of water that could potentially be available for oil shale development.

It is apparent that, with Colorado having only 167,000 acre-feet of water available for development in the Upper Basin and with a 500,000 acre-feet annual water supply in the White River at the Colorado-Utah state line, there should be sufficient water remaining in the White River for development in Utah.

The water right for oil shale development in Utah will require a Utah water right. The water right application for 250,000 acre-feet of water per year held by the Utah Board of Water Resources (No. 36979 filed May 19, 1965) is by far the largest applied for in Utah.

The Ute Indian tribe claims water rights sufficient to irrigate about 13,400 acres of reservation land on the White River. The tribe is currently developing about 3,300 acres of this land.

The state of Utah through its state comprehensive water planning program, "The State of Utah Water - 1975" (Ref. 3-11), recommends that a dam and reservoir be built on the White River to supply water for oil shale development in Utah and for irrigation of Indian lands. It is anticipated that

the Utah Board of Water Resources water rights application, along with Ute Indian Tribe Winters Doctrine water rights, would be used for this development.

3.14.1.5 White River Dam Site

The site selected for the dam to be built on the White River is located near the center of Section 17, T10S, R24E, SLB&M. The choice was based on factors such as: the structural competence of the foundation of the dam site, the environmental impact on the inundated area, reservoir efficiency, preliminary cost comparisons, and location with respect to oil shale development.

3.14.2 PHASE I SYSTEM

3.14.2.1 Water Requirements

The water requirements for Phase I are indicated in Table 3.14-1. As shown, the average consumption is estimated to be 1,409 gpm or 2,270 acre-feet per year.

Table 3.14-1
PHASE I WATER REQUIREMENTS^(a)

Use	Annual Average	
	Gallons per Minute	Acre-Feet per Year
Cooling Tower Evaporation	480	775
Shale Quenching and Dust Control	704	1,135
Other Miscellaneous Losses Including Evaporation	225	360
Total Consumption	1,409	2,270

(a) Dry year basis. No allowance for annual rainfall.

3.14.2.2 Facilities

The water supply facilities for Phase I consist of:

- An intake pumping station located on the south bank of the reservoir on the White River
- A 1.7 mile pipeline from the intake
- A storage tank at the terminal end of the pipeline
- A water distribution network in the plant area

3.14.2.3 System Description

Raw water for plant use will be obtained by pumping from an intake system that will withdraw water from the reservoir to be constructed on the White River Dam by the state of Utah.

The pumping station will consist of a fully enclosed surface structure housing pumps, motors, and electrical and mechanical systems, including full remote control for the process plant. It will have the capacity to pump the average water requirement, will allowance for peak plant demands.

Delivery will be through a 24-inch-diameter pipe to a 56,000-barrel-capacity steel storage tank. The storage tank will provide operational flexibility and reserve storage for fire protection. This tank will be used for oil storage during commercial production phase operations.

Water will be pumped from the storage tank to the process area. All pipelines will be buried below the frost depth for freeze protection and will be protected against corrosion, as required.

Electric power for the pumping station will be obtained from the process plant's 138 or 69 kV distribution.

Water required during the construction of the process plant will be obtained from the White River by tanker trucks or other temporary means.

3.14.3 PHASE II AND III SYSTEM

Both surface water and groundwater resources will change in Phases II and III. These changes are discussed in Section 5.2.

3.14.3.1 Water Requirements

The ultimate Phase III water requirements are estimated to be 16,807 gpm or about 27,100 acre-feet per year, as shown in Table 3.14-2. A further discussion is found in Section 7.14.

Table 3.14-2
PHASE III WATER REQUIREMENTS^(a)

Use	Annual Average	
	Gallons per Minute	Acre-Feet per Year
Cooling Tower Evaporation	11,180	18,050
Shale Quenching and Dust Control	5,000	8,050
Other miscellaneous Losses including Evaporation	627	1,000
Total Consumption	16,807	27,100

(a) Dry year basis. No allowance for annual rainfall.

3.14.3.2 Facilities

The water supply facilities for Phases II and III consist of:

- An expanded pumping station located on the south bank of the reservoir on the White River (originally constructed during Phase I)
- An extended 24-inch diameter pipe (originally installed during Phase I) to an on-tract storage pond
- An on-tract storage pond at the terminal end of the pipeline
- An expanded water distribution system in the plant area

3.14.3.3 System Description

Raw water for plant and processed shale uses will be pumped from the White River Reservoir through a 24-inch-diameter pipeline.

The pumping station at the reservoir will be a fully enclosed structure housing screened intakes, pumps, motors, electrical switchgear, and mechanical systems. The pumps will be capable of pumping the average water requirement, with allowance in capacity for peak demands. Supervisory and telemetering equipment will be included to provide full remote control from the process plant control room. Electric power supply for the pumping station will be provided from the White River Shale Project power distribution system.

The on-tract freshwater storage pond will be constructed to provide operational flexibility, including 3 days of reserve and additional storage to maintain a reliable supply of water during an outage of the reservoir pumping station or pipeline and to control drainage water. Although no subsurface exploration or material testing have been performed, the pond will be formed by an earthfill dam constructed by making maximum use of local materials.

Water will be distributed from the pond to the plant and to the processed shale disposal area by an outlet system that will permit the flow to be synchronized for delivery to either the plant or the processed shale area or both. The plant demand and the processed shale moisture control requirement will be delivered by gravity from the storage pond through a 42-inch-diameter pipeline to the water treatment plant prior to pumping to the water use point.

All pipelines will be buried below the frost depth for freeze protection and will be protected against corrosion, as required.

3.14.4 WATER TREATMENT

During Phase I, raw water (White River water) stored in a tank will be pumped to the water treatment plant consisting of a media filter and chlorinator. Water used for boiler feedwater makeup will be deaerated and demineralized by ion exchange.

During Phases II and III, raw water (White River water) stored in the reservoir will be delivered by gravity to the water treatment plant, which will consist of a flash mixer, a flocculation tank, a sedimentation tank, and a media filter.

Treated water (70 gpm during Phase III) will be chlorinated for use as drinking water, in sanitary facilities, and in the cafeteria. Water used for boiler feedwater makeup will be deaerated and demineralized by ion exchange.

Potable water, process water, and boiler makeup water will be stored in three separate storage tanks, each with 12 hours of minimum supply capacity. Each treatment system will be designed to provide a guaranteed supply of treated water. The water treatment plant will be located at the southwest corner of the process area.

3.15 WASTEWATER MANAGEMENT PLAN

The wastewater management plan for the White River Shale Project is aimed at water conservation through maximum reuse of treated wastewater.

3.15.1 SEQUENCE OF DEVELOPMENT

The wastewater management plan involves a three-phase development of collection and treatment facilities. These phases are based on requirements during construction and operation of the three phases of WRSP process facilities. The sequence of development and the duration of use of the different wastewater collection and treatment facilities are shown in Figure 3.15-1.

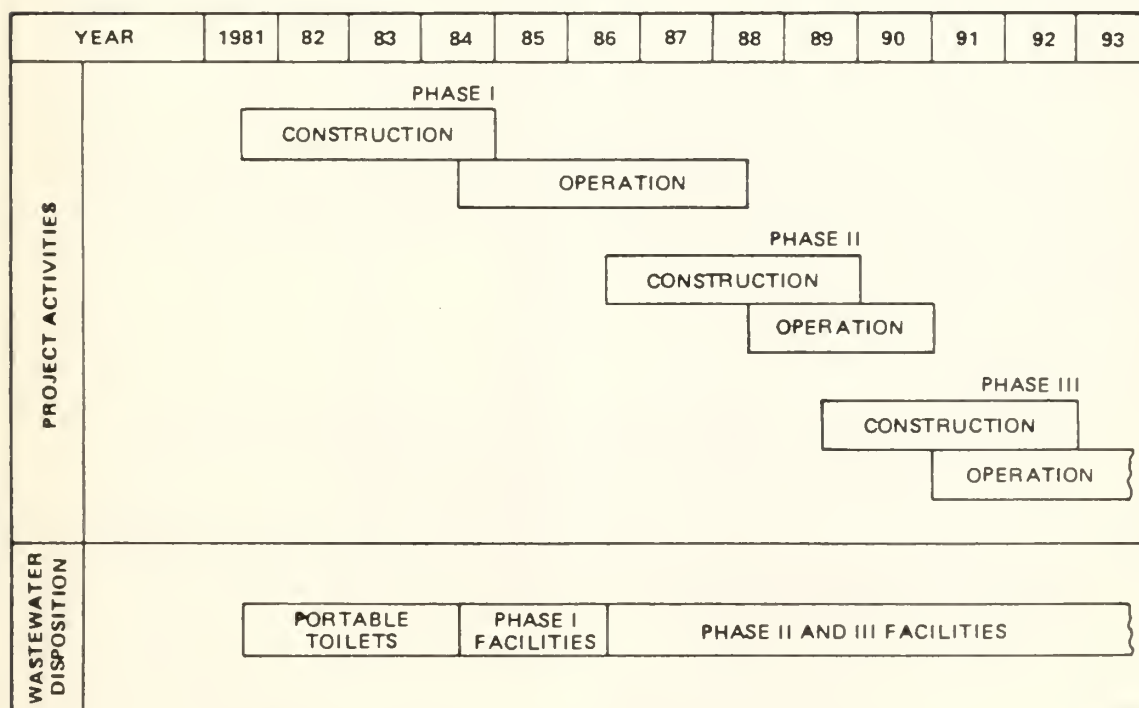


Figure 3.15-1 WASTEWATER MANAGEMENT SCHEDULE

During the early part of construction of Phase I, portable toilets will be used for sanitary waste disposal.

A wastewater collection and treatment facility will be developed for use during the latter part of Phase I construction and during Phase I operations.

A separate system of wastewater collection and treatment will be provided to handle expected wastewater flows during Phase II operation and during construction and operation of Phase III.

Water use and wastewater flow rates are shown in Figure 3.15-2 for Phase I and in Figure 3.15-3 for Phases II and III. The scheme for collection, treatment, and reuse will be basically the same during the three phases. However, the wastewater flow rates will be different because of the substantial variation in the process units employed in each stage. A summary of the wastewater sources, methods of collection, and treatment and reuse schemes follows.

3.15.2 WASTEWATER SOURCES AND CHARACTERISTICS

Maximum reuse of treated wastewater will require that the wastewater streams be segregated and treated according to the type and level of contaminants they contain.

The major wastewater streams are:

- Oily Wastewater. This is mainly from washdown of the process and utility plant areas. Major contaminants include oil, suspended solids, and dissolved organics.
- Sour Water. This comes from the process facilities. Major contaminants include ammonia, sulfide, phenols, and other organics.

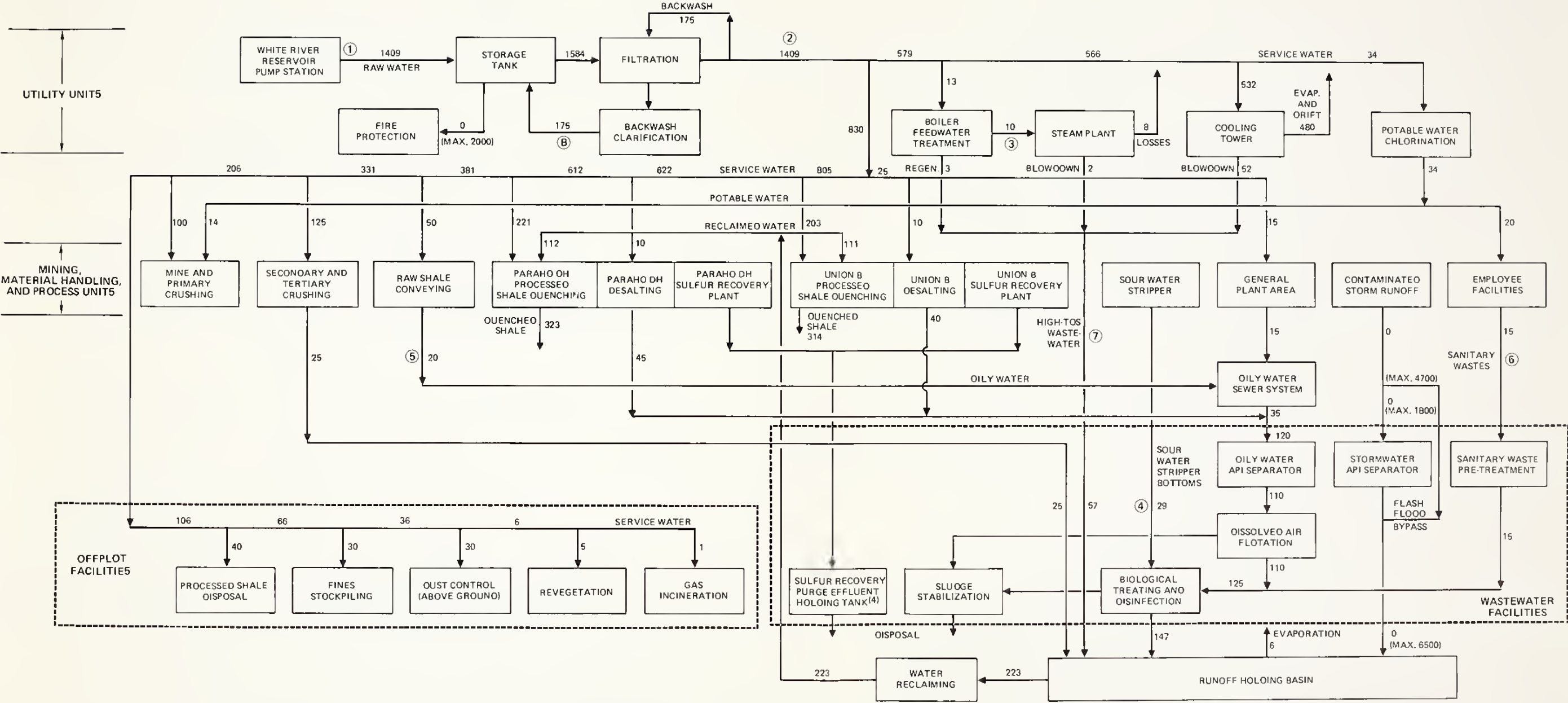
WATER AND WASTEWATER CHARACTERIZATION (ESTIMATED)									
Stream Number		①	②	③	④	⑤	⑥	⑦	⑧
Designation		Raw Water	Service Water	Boiler Feed Make-up	Sour Water Stripper Bottoms	Oily Water	Sanitary Waste-water	High-TDS Water	Spent Raw Water Backwash
Flow, Phase I	GPM	1409	1409	10	29	20	15	57	175
pH		7-8.5	7-8.5	9-10	8.5-9.5	7-9	7.0-8.5	6.5-7.5	7-8.5
Dissolved solids	mg/l	400-800	400-800	50-100		500-2000	800-1000	5000-10,000	400-800
Suspended solids	mg/l	300-1000	20-50	Nil		30-2000	200-300	100-500	3000-10,000
Chemical oxygen demand	mg/l			Nil	500-1500	100-2000*			
Biochemical oxygen demand	mg/l			Nil		50-500*	150-250		
Oil and grease (total)	mg/l	0-5	Nil	Nil	50-100	50-1000	20-50		0-50
Phenols	mg/l	<1	<1	Nil	80-150		<1		<1
Ammonia	mg/IN	<1	<1	Nil	25-50		10-15		<1
Total phosphate (PO ₄ ⁻³)	mg/l	0-1	0-1	Nil			5-10		0-1
Total hardness (as CaCO ₃)	mg/l	200-350	200-350	<5					200-350
Total alkalinity (as CaCO ₃)	mg/l	150-250	150-250	<5					150-250
Hydrogen sulfide	mg/l	Nil	Nil	Nil	<10	<10	Nil	Nil	Nil

*Filtered sample

WATER BALANCE SUMMARY (GPM)

Source	Disposition		
Fresh water supply	1409	634	Processed shale quenching
		70	Dust control at disposal site
		480	Cooling tower evaporation and drift
		225	Miscellaneous
		1409	1409

- Notes:
- (1) All flows are estimated annual (dry weather) averages in gallons per minute (GPM) unless noted otherwise.
 - (2) The diagram assumes little or no water produced within the mine.
 - (3) Quantities and dispositions of oils and solid wastes associated with the wastewater systems are not shown in this diagram. Generally these will accumulate intermittently and at low rates except for waste treatment sludges.
 - (4) When a purge of the sulfur removal plant(s) is in effect, the effluent therefrom will be collected in the holding tank at a rate of about 2.5 GPM, and will probably be disposed of batch-wise.
 - (5) Water losses not specifically depicted above include water vapor in burned gases, free and bound water in solid wastes, residual water in the product oil, water lost by mechanical equipment, and some minor losses due to natural evaporation.
 - (6) The assumed basis for shale quenching is 21 percent (dry basis) water by weight of the processed shale.



WATER AND WASTEWATER CHARACTERIZATION (ESTIMATED)								
Stream Number	①	②	③	④	⑤	⑥	⑦	⑧
Designation	Raw Water	Service Water	Boiler Feed Make-up	Sour Water Stripper Bottoms	Dily Water	Sanitary Waste-water	High-TDS Water	Spent Raw Water Backwash
Flow — Phase II	GPM	8484	6260	90	305	366	583	853
Phase III	GPM	16,604	12,514	173	598	728	1166	1628
pH		7-8.5	7-8.5	9-10	8.5-9.5	7-9	7.0-8.5	6.5-7.5
Dissolved solids	mg/l	400-800	400-800	50-100		500-2000	800-1000	5000-10,000
Suspended solids	mg/l	300-1000	20-50	Nil		30-2000	200-300	100-500
Chemical oxygen demand	mg/l			Nil		100-2000*		
Biochemical oxygen demand	mg/l			Nil		50-500*		
Dil and grease (total)	mg/l	0-5	Nil	Nil	50-100	20-50		0-50
Phenols	mg/l	<1	<1	Nil	80-150	<1		<1
Ammonia	mg/l	<1	<1	Nil	25-50	10-15		<1
Total phosphate (PO ₄ ⁻³)	mg/l	0-1	0-1	Nil		5-10		0-1
Total hardness (as CaCO ₃)	mg/l	200-350	200-350	<5				200-350
Total alkalinity (as CaCO ₃)	mg/l	150-250	150-250	<5				150-250
Hydrogen sulfide	mg/l	Nil	Nil	Nil	<10	<10	Nil	Nil

* Filtered sample

WATER BALANCE SUMMARY (GPM)

Source	Disposition			
	Phase II	Phase III	Phase II	Phase III
Fresh water supply	8484	16,604	2590	5000
			5580	11,180
			469	627
	8484	16,604	8639	16,807

Notes:

- (1) All flows are estimated annual averages in gallons per minute for Phase II/Phase III.
- (2) Diagram assumes little or no water produced in the mine.
- (3) The retorting box represents retort(s), processed shale quenching facilities, and all processing units except desalting, sulfur recovery, and sour water stripping.
- (4) Gas scrubber wash water makeup.
- (5) The coarse shale IH retort box represents the retort, shale quenching facilities, desalter, and all processing units except sulfur recovery and sour water stripping.
- (6) Desalter and product gas wash.
- (7) Excludes the desalter for the coarse shale IH retort.
- (8) Scrubber makeup.
- (9) Assumed basis for shale quenching is .21 lb of water/lb of dry shale for Paraho DH and Union 8, 0.14 lb of water/lb of dry shale for Tosco II.

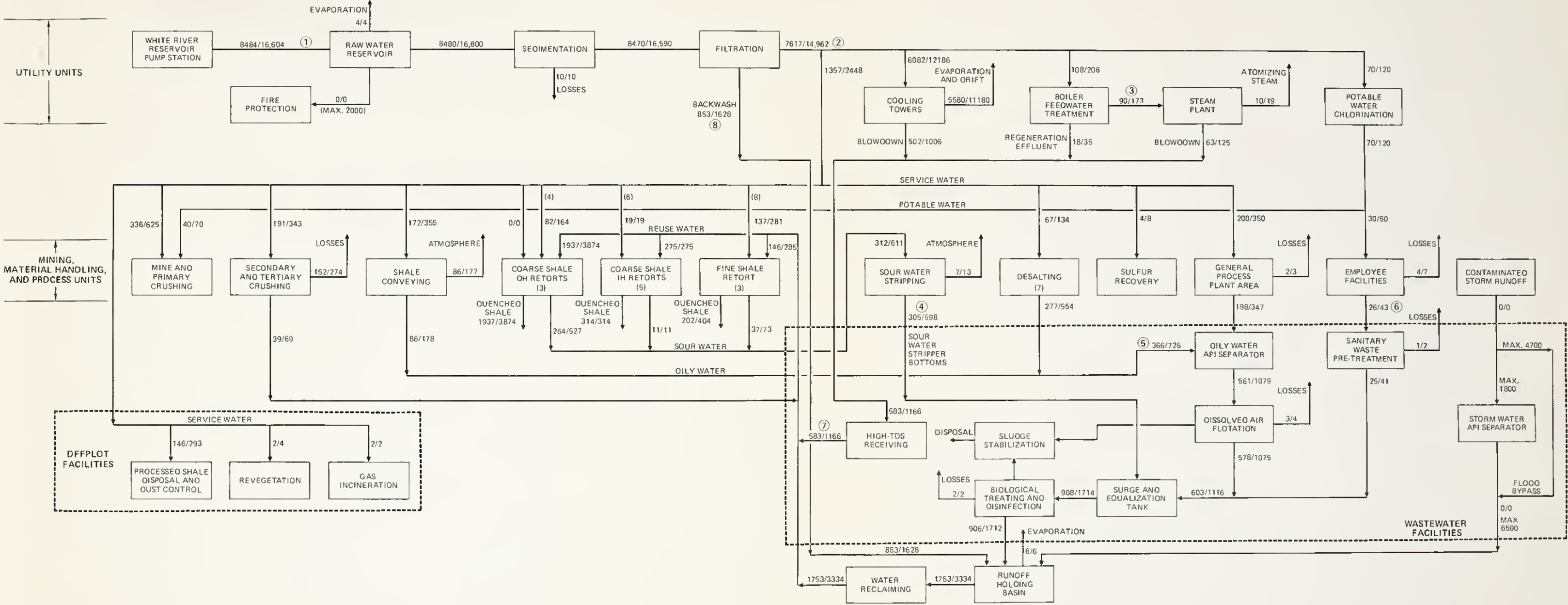


Figure 3.15-3 PHASES II AND III WATER AND WASTEWATER HANDLING SYSTEM



- Sanitary Wastewater. This comes from employee facilities. Major contaminants include suspended solids, organics, and nutrients. Portable toilets are used in the mine. The chemicals used in these toilets are biodegradable.
- Blowdown. This comes from the steam system and cooling tower in the utility plant and various process units. Major contaminants include dissolved inorganics.
- Storm Runoff. Runoff comes from contaminated and potentially contaminated areas. Major contaminants include suspended solids and, occasionally, oil.
- Mine Water. Water from the mine is expected to be saline, but its production rate is expected to be low. If the production rate is sufficient, the water will be used for dust control inside the mine, thus reducing the overall freshwater demand. Any remaining water will be used in other project activities, such as surface dust suppression.

An inventory of the wastewater streams expected during all phases is shown in Table 3.15-1. The flows during Phase II operation are expected to be about 50 percent of those estimated for full commercial (Phase III) plant operation.

3.15.3 WASTEWATER COLLECTION

The wastewater streams will be segregated and collected in separate sewers and/or pipes according to the type and level of contamination. There will be four separate sewer systems:

- Oily. The oily sewer network will receive the stripped sour water and plant washdowns.
- High TDS. Blowdown from the utility plant and from various process units will be collected through the high-TDS sewer network and discharged into the high-TDS storage tank. Excess mine water (saline water), if present, will also be collected and discharged into the high-TDS storage tank.
- Sanitary. Wastewater from all aboveground employee facilities will be collected through a sanitary sewer network and discharged into a primary sedimentation tank. Sanitary wastewater generated in the mine will be collected

Table 3.15-1

WASTEWATER STREAMS SUMMARY

Wastewater Stream	Source	Flow (GPM)		Major Contaminants	Collection
		Phase II	Phase III		
Sour Water	DH Retorts	264	527	Organics, ammonia phenol, sulfides	Sour water sewer
	III Retort	11	11		
Oily Water	Fine Retort(s)	37	73	Organics, inorganics	Oily water sewer
	Shale Conveying Desalting	86	178		
Blowdown		280	550	Inorganic salts	High-TDS Sewer
	Cooling Towers BW Treatment Steam Plant	502	1,006		
Washdown		18	35	Organics, suspended matter	Oily water sewer
	General Process Area	63	125		
Sanitary Wastewater		200	350	Suspended matter, organics, nutrients	Sanitary sewer
	Employee Facilities	26	43		
Contaminated Storm Runoff	General Plant Area	45 acre-feet		Suspended matter, organics	Storm sewer, culverts, ditches
Saline Mine Water	Groundwater	Nil	Nil	Inorganic salts	Dust control inside mine. Any excess for processed shale wetting.

in portable toilets; the liquid in these toilets will be recycled and solids stored in a tank attached to the toilets. When the storage tank is full, its contents will be transferred to the sanitary sewer through which they will reach the aboveground treatment system.

- Stormwater. Runoff from contaminated and potentially contaminated areas (including the process area, tank farm, shale stockpiles, and product pipeline pump station) will be collected through a network of gutters, culverts, and sewers and discharged into the stormwater screening and dewatering basin (see Section 3.13). If there is runoff from the processed shale disposal site in Southam Canyon, it will be captured in an impoundment at the north end of the canyon (see Section 3.10).

The sanitary, oily, and stormwater sewer flows will be combined, after treatment, to form the low-TDS wastewater stream.

3.15.4 WASTEWATER TREATMENT SYSTEM

The wastewater treatment concept is based on preventing wastewater discharge to the White River through complete use and reuse of the treated wastewater. The water requirement of 27,100 acre-feet per year for Phase III was used in developing the water balance shown in Figure 3.15-3.

As shown in Figure 3.15-2 and 3.15-3, the wastewater streams will be segregated on the basis of type and level of contamination.

Process wastewater streams that contain high TDS concentrations will be collected and routed to the storage tank without treatment. These streams are expected to contain primarily inorganic salts and small amounts of organics and nutrients.

Sanitary wastewater collected from employee facilities will be routed to a sedimentation basin and then to biological oxidation treatment units. The biologically treated effluent will be disinfected and discharged to the wastewater and storm runoff holding basin.

Oily water from desalting, shale conveying, and plant washdown will be discharged into an API separator and flotation unit and then into a surge-equalization basin. The sour water stripper bottoms stream will be routed directly to the flotation unit. The flotation unit effluent will then be discharged to the low-TDS wastewater storage pond.

Plant area runoff expected from the 100-year frequency storm will be impounded in the holding basin. The impounded water will be screened, degrittied, and then deoiled, if necessary.

The foregoing wastewater treatment concept is based on the assumption that little mine water will be produced. However, if mine water production is substantial, the excess mine water will be used for wetting the processed shale. The effluent from the holding basin will be treated further by a biological oxidation process to reduce its organic content and may be used as a cooling tower makeup.

Skimmed oil and oily sludges collected in sumps, oil separators, manholes, etc., will be held in a slop tank and processed for recovery. The stabilized biological sludge will be temporarily stored until it can be used at the processed shale disposal site for soil conditioning.

3.15.5 WASTEWATER REUSE

Reuse of the following wastewater streams during commercial plant operation is planned:

- Sour Water. The sour water streams will be stripped in a separate sour water stripper before transport to the wastewater treatment facilities at a rate of 600 gpm (305 gpm in Phase II).
- Clean Condensate. All clean condensates generated in the process and utility plants will be segregated and reused as boiler feedwater. This stream is expected to amount to 6,866 gpm (3,430 gpm in Phase II).

- Combined Wastewater. After appropriate treatment, the sanitary, oily wastewater, and blowdown streams will be reused as processed shale moisturizer water. These flows are expected to total 5,050 gpm (2,612 gpm in Phase II).
- Stormwater. The stormwater collected in the process area will be treated and then reused, along with other wastewater, as processed shale moisturizer water. The runoff collected at the processed shale disposal site will be used for dust control and compaction purposes at the site.

3.16 CORRIDOR PLANNING

3.16.1 CORRIDOR DEVELOPMENT PROGRAM

The Bureau of Land Management (BLM) has developed a program for routing transportation and utility services in a few selected patterns on BLM-administered land. Using existing routes as a guide, the BLM has evaluated known developable resources as well as existing land uses and has selected routings, known as corridors, to be used on a preferred basis by future installations. These corridors are intended for multiple use wherever possible so that roads, pipelines, etc., that follow roughly parallel routes can be grouped together. The purpose of selecting corridors is to minimize environmental impact on the area while still providing all necessary services.

3.16.2 ACCESS ROADS

The Vernal area will probably furnish the major location for permanent housing for workers employed on the project. Therefore, access from Vernal has been considered the primary corridor to the project. The existing corridor from Vernal is southeast along U.S. 40 to Route 45, south along Route 45 through Bonanza and across the White River to a point about three-quarters of a mile inside the northern boundary of Tract Ub, and then southwest along a new road to the plant site (see Figure 3.16-1).

The corridor for the access road will be the same in all phases. Major improvements and new construction will take place in the section between Bonanza and the plant site; maintenance and minor improvements will be made along the remainder of the access road.

For Phases II and III, improvements will be made to Route 45 between U.S. 40 and Bonanza. No major improvements are planned on U.S. 40. In the near future, Uintah County plans to complete a new highway from Vernal to Bonanza. This new road will then carry a majority of traffic from the west. Other routes are also being investigated by Uintah County.

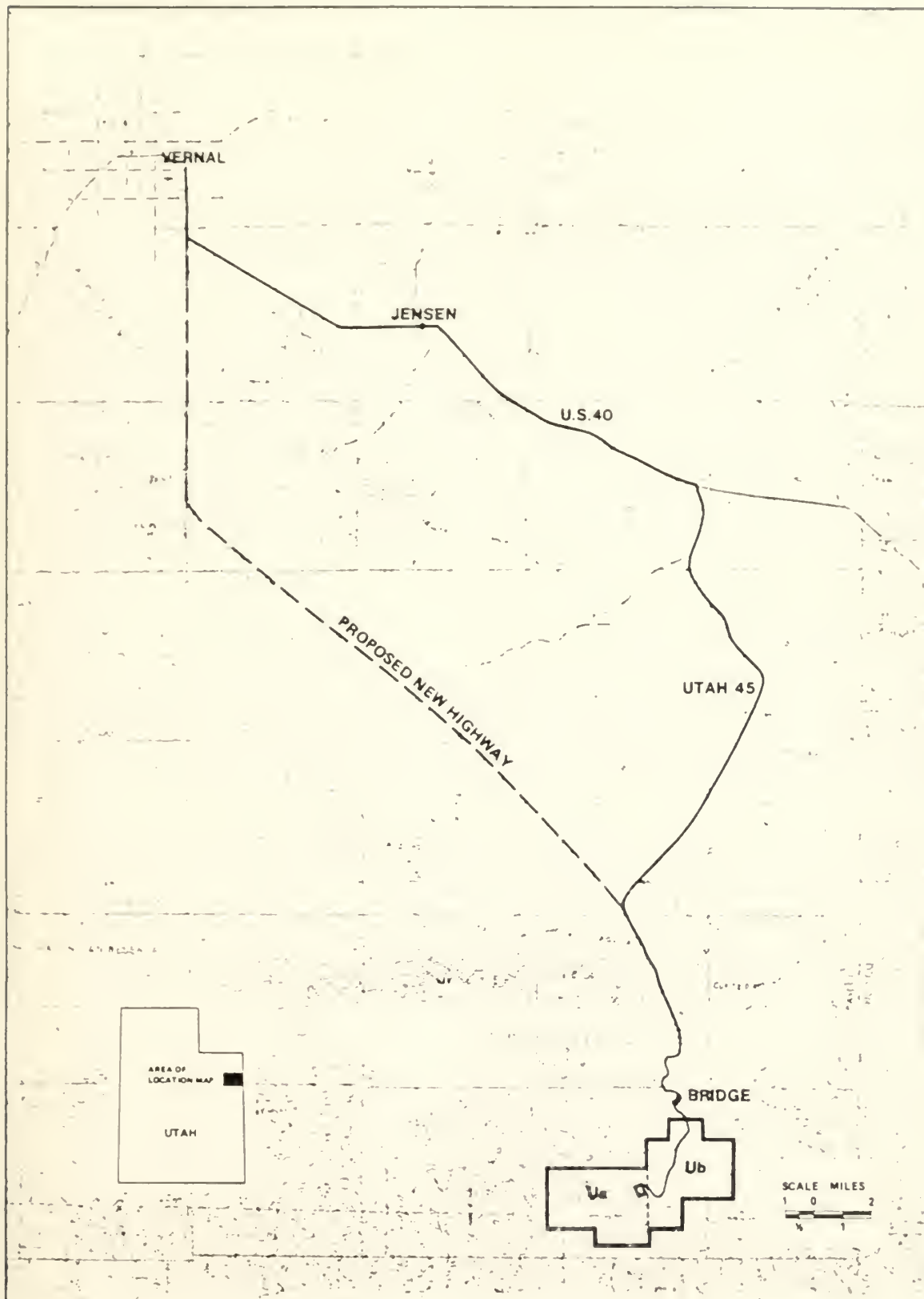


Figure 3.16-1 CORRIDORS TO WRSP SITE

3.16.3 POWER LINES

The existing corridor from the substation at Vernal to the substation at Bonanza will be used to expand the service to 69 or 138 kV. From Bonanza to the plant site, the new line will share the access road corridor. The line will be built during the Phase I construction period and will be completed before Phase I startup.

Electrical power to miscellaneous offsite places, such as the processed shale disposal area and water supply pumping station, will be distributed from the substations in each phase. The distribution line to the water pumping plant will follow the water supply line route. Power to the processed shale disposal area will follow the conveyor and its maintenance road route.

3.16.4 WATER SUPPLY LINES

The water supply system from the White River Reservoir will be completely on tract; there will be no off-tract corridors. The raw water supply line will run from the pumping plant to the plant site area (see Figure 3.4-1).

In Phase I, the raw water supply line will terminate at the raw water tank. From there, water will be distributed throughout the plant area. There will be a 2 mile water line to the processed shale disposal area in this phase. Any additional water required for uses such as dust control, drinking water, etc., will be hauled in tanks and trucks.

In Phases II and III, the raw water supply line will run from the pumping plant to the water reservoir south of the plant site. All river water used in the project will be distributed from the on-tract reservoir. A pipeline will be run from the reservoir to the processed shale disposal area. In the processed shale disposal area, much of the line will be irrigation-type piping that can be moved with the operation as required.

3.17 PRODUCT TRANSPORT

During Phase I operation, the raw shale oil will be transported by truck. During Phases II and III, it will be transported by buried pipeline.

The proposed pipeline will transport raw shale oil from the White River Shale Project facility in northeastern Utah to Borger, Texas. A major refinery complex at Borger will be adapted to refine the raw shale oil to a full range of petroleum products.

3.18 BY-PRODUCT PLAN

In the most probable plan of operation, the project will generate the following quantities of sulfur by-product:

- Phase I : 20.6 TPSD
- Phase II : 75.6 TPSD
- Phase III : 139.2 TPSD

During Phase I, the sulfur by-product will be stockpiled. During the commercial phases of the project, sulfur will be trucked to available markets in the chemical industry, if any are identified.

During all project phases, ammonia generated by gas treating will be disposed of by incineration in a reducing burner that will minimize NO_x emissions.

3.19 CONSTRUCTION PLAN

This section describes the plan for construction of oil shale mining and processing facilities at Tracts Ua and Ub. This plan includes all field operations necessary for establishing access and moving workers, equipment, and materials into the area; housing workers at the Bonanza campsite; and constructing all facilities at the mining site. Construction will include excavating and preparing the site and installing all buildings, equipment, and support structures necessary to implement each phase. All construction materials and equipment will be shipped by rail to Craig, Colorado (the nearest railhead), and trucked to the plant site. Alternatives to this plan are described in Section 7.

3.19.1 CONSTRUCTION PHASES

The mining development program will proceed in three major phases, and each phase will involve operations at the mining site. (These phases are shown on the project schedule in Section 3.1.) Construction operations have been carefully planned and phased to allow orderly development of the mining facility, to minimize construction costs and unnecessary excavations, and to avoid causing adverse environmental effects. The construction phases are defined in the following paragraphs.

3.19.1.1 Phase I

Phase I mine development will include the sinking of three vertical mine shafts and the excavation of sufficient horizontal mine openings needed to produce 26,700 tons per stream day (TPSD) of raw shale. During this period, approximately 3,000,000 tons of oil shale and other rock will be removed. Retorting-grade oil shale will be stockpiled prior to retort startup. The waste rock will be disposed of appropriately, or used as fill material.

The mine development work will require approximately 200 men and the transport of 10,000 tons of material to the site.

Plant construction of the two retorts during this phase will require a peak work force of about 1,100 men and 50,000 tons of materials and equipment at the site. To allow transport of men and materials, the roads leading to the site must be improved before construction activities can begin. The raw oil to be trucked from the site during the facility operation will also require improvements to the access roads.

3.19.1.2 Phases II and III

During Phases II and III, the commercial production plant will be built, and the mine will be brought to full-scale production by sinking and equipping on a phased basis, four or more additional ventilation shafts and two declines. This will require a work force of about 400 men and 30,000 tons of material and equipment.

Oil shale removed for expansion of the underground portion of the mine will be stockpiled until the plant is operational. The mine will be developed in two phases to coincide with the completion of the first and second trains.

Building the two process trains and their supporting facilities will be the main construction effort of the WRSP program. Consisting of two overlapping phases (Phase II for the first train and Phase III for the second) totaling 6 years in length, this effort will include major earth-moving operations, foundation laying, and equipment installation. It will require a peak work force of 3,200 manual and non-manual workers and transport of 350,000 tons of material and equipment to the construction site.

3.19.2 CONSTRUCTION MANPOWER SCHEDULE

A schedule of manpower needed for mine development and plant construction and operation is shown in Figure 3.19-1. Since mine development is a continuing activity, the mining work force grows smoothly throughout the project phases until it levels off at 1,678 men at full production. In contrast,

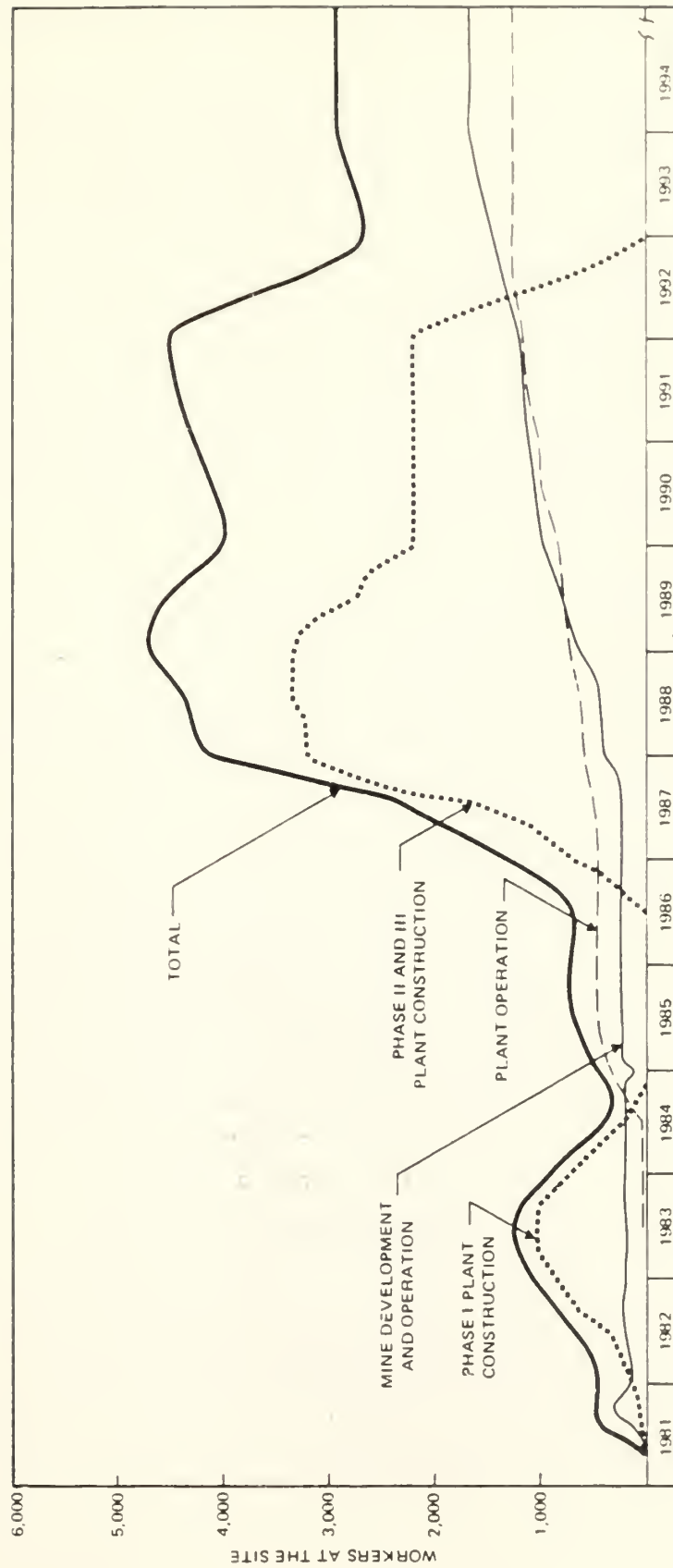


Figure 3.19-1 MANPOWER SCHEDULE

the plant construction work force is temporary and peaks at about 1,100 men in Phase I and 3,200 men in Phases II and III. The total work force at the site will also include plant operating personnel, as discussed in Section 3.20.

3.19.3 CAMPSITE DEVELOPMENT

Construction workers will make a sizable transient addition to the local population. To help minimize adverse socioeconomic effects in the area, a temporary campsite will be established to provide housing, services, and recreation for site workers, and for those indirectly employed who will provide goods and services.

The campsite will be located near Bonanza, 5 miles north on Highway 45, across the White River from the construction site. It will consist of modular, transportable bachelor units and eating, shopping, and recreation facilities. It will be naturally landscaped to fit the terrain and will provide modern utilities.

3.19.3.1 Campsite Population

The campsite will be initially established during Phase I and expanded as the work force increases. Estimators from the WEA Study (Ref. 3-12) established requirements for the campsite. Using their estimates and the number of construction and operation workers shown in Figure 3.19-1, the projected campsite population is calculated to peak at about 3,000 people in the tenth year.

3.19.3.2 Campsite Utilities

The campsite will require telephone lines, electric power lines, a potable water supply, wastewater treatment, and solid waste disposal. The estimated peak requirements for these utilities are shown in Table 3.19-1.

Table 3.19-1

CAMPSITE UTILITIES

Utility	Phase I Construction	Phases II and III Construction
Telephones	110	550
Electric Power	3 MW	10 MW
Potable Water	100,000 gpd	400,000 to 700,000 gpd

3.19.3.3 Utility Development Schedule

Before Phase I begins, telephone lines, electric power lines, and potable water lines will be brought in from Bonanza. Wastewater will be treated by a packaged facility installed at the campsite, and solid waste will be disposed of by sanitary landfill. If the peak electric power demand of 13 MW exceeds the local supply capacity, temporary engine-driven electric power generators will be installed at the construction site and lines will be installed to bring the power to the campsite. However, present local utility plans are to increase the local supply capacity.

3.19.4 SITE ACCESS

Construction materials and equipment will be shipped by rail to Craig, Colorado, and then trucked west on U.S. Highway 40 and south on State Highway 45 through Bonanza and across the White River to the site, a distance of 120 miles. With over 400,000 tons of material required, the average work-day traffic into the site will be 25 tons of material per day. Peak rates could be much higher and individual truck loads for

transporting heavy equipment, concrete mix, and other structural materials could reach 100 tons.

To handle this frequent and heavy traffic, Highway 45 will be upgraded between Bonanza and a point 2 miles south of the White River about 1 mile into the tract area. A new road will be cut and paved from this point to the building site. These road improvements will be made before Phase II begins.

3.19.5 SCHEDULE OF FIELD OPERATIONS

The field operations for constructing the WRSP facility have been planned for orderly implementation of the three construction phases. The major onsite construction tasks are site excavation, foundation work, and equipment installations, as shown in Figure 3.19-2 and described below.

3.19.5.1 Site Excavation

The main earth-moving operations will be required in the first 9 months of Phase I and in the first 12 months of Phase II. These will include leveling areas for buildings, parking, and plant construction; grading on-tract access roads; and excavating for the water supply reservoir, drainage control, and wastewater collection ponds. An estimated 200,000 cubic yards of earth will be moved in Phase I and another 800,000 cubic yards in Phase II when site excavation work is completed. Two methods will be used about equally: "blast and fill" and the more conventional "rip and haul." Rock crushers on site will reduce the size of rocks loosened by blasting to allow all of the material to be used for fill. Cut slopes will be 1:1 and fill slopes 2:1 (horizontal:vertical). A minimum of excess material will be dumped in the processed shale area.

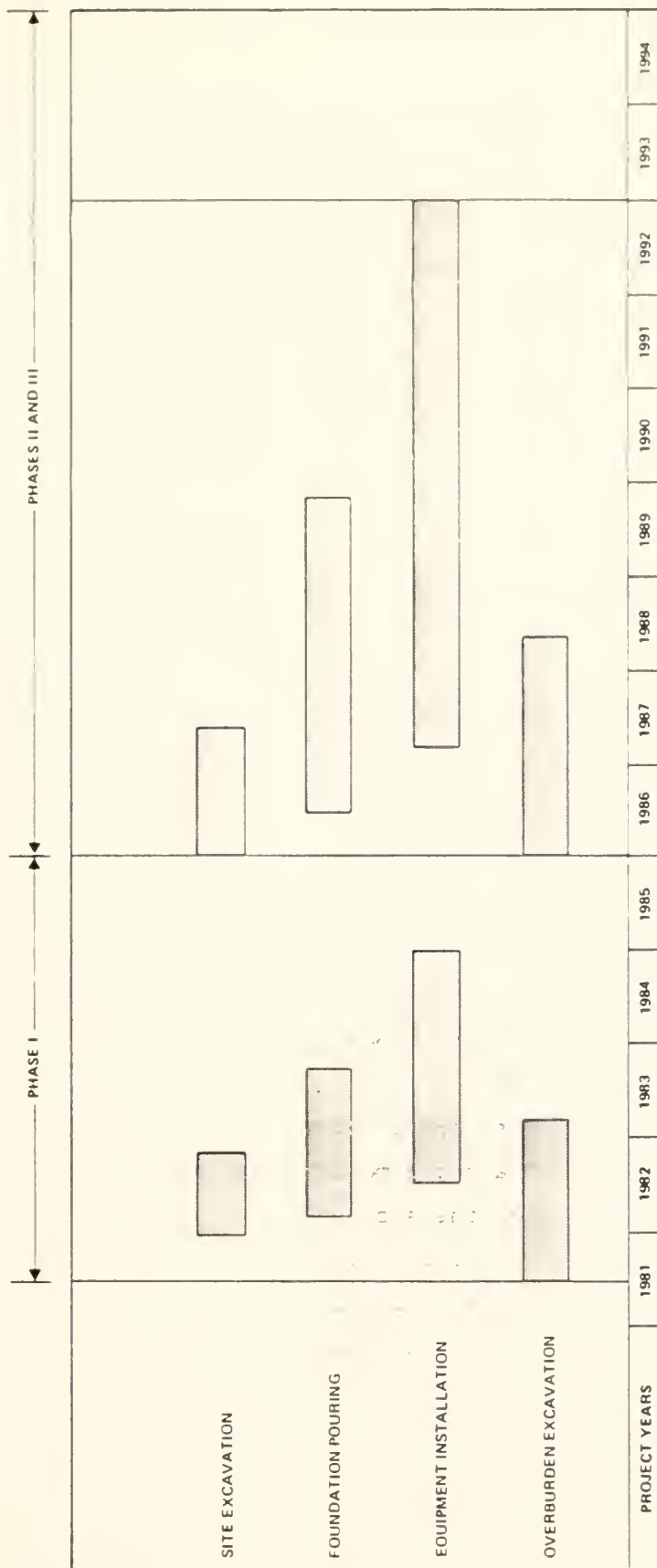


Figure 3.19-2 SCHEDULE OF CONSTRUCTION OPERATIONS

3.19.5.2 Foundation Work

Concrete mix will be hauled to the site, mixed on site, and poured for building and equipment foundations. A total of 20,000 cubic yards of concrete required for Phase I will be poured at an average rate of 100 cubic yards per day in the summer months of 1982 and 1983.

For Phase II, a total of 80,000 cubic yards will be poured at an average rate of 400 cubic yards per day in the summer months of 1986, 1987, and 1988. Peak output from the mixer could reach 500 cubic yards per day.

3.19.5.3 Equipment Installation

Installation of equipment includes all machine setting, piping, sheet metal, electrical work, and erection of support structures. For Phase I, equipment installation will begin in the first quarter of 1982 and end in the third quarter of 1984 at the completion of the Phase I plant. For Phases II and III, equipment installations will begin in 1987 and proceed to completion of the full-size plant in the end of 1992.

3.19.5.4 Mine Shaft Excavation

Three access shafts will be sunk during Phase I. Four or more additional ventilation shafts and two declines will be sunk during Phases II and III. The estimated 200,000 to 300,000 cubic yards of earth and rock removed from these shafts will be used as fill when it is of suitable quality. The remainder will be dumped in the processed shale area or stockpiled for revegetation, depending upon its quality.

3.19.6 CONSTRUCTION POLLUTION CONTROL

An environmental protection program has been designed to minimize detrimental environmental effects during site preparation and plant construction. This program includes control measures for noise and fugitive dust from various construction activities, proper disposal of solid wastes, control of erosion and runoff, and treatment and disposal of wastewater.

3.19.6.1 Fugitive Dust Control

During construction, fugitive dust will arise from activities such as the operation of heavy equipment, blasting, truck traffic, and operation of the concrete batch plant. To prevent fugitive dust from becoming airborne, the following steps are to be taken:

- Areas regularly traversed by heavy equipment will be dampened frequently and in some cases graveled or oiled.
- Wherever feasible, areas will be landscaped to minimize wind erosion.
- Main roadways and parking lots will be paved and maintained.
- Whenever feasible, blasting will be done in a manner that generates a minimum amount of dust.
- In the dumping and loading areas of the concrete batching plant, conveyors and elevators will be enclosed. Storage bin vents will have dust removal devices, and, wherever applicable, water spray will be used for dust control.

3.19.6.2 Construction Wastes (Solid Waste)

Construction debris — such as lumber, packing material, scrap metal, rubber, asphalt products, broken concrete, and other related solid waste — will be collected and disposed of in the processed shale disposal site. The collection and disposal methods are discussed in detail in Sections 4.3 and 3.11.

3.19.6.3 Construction Liquid Wastes

Liquid wastes from construction activity will include dirty lubricant oil, sanitary wastewater, pipe test and flushing water, and related liquid chemical waste.

Waste lubricant oil from construction equipment and vehicles will be deposited in a central collection tank for salvage and subsequent removal to an offsite location for proper disposal.

During the initial phase of construction, chemical toilets will be provided and serviced by a contractor. These toilets will not use an external water supply, nor will they discharge any liquids or solids on site. Upon completion of the sanitary wastewater treatment plant, toilets (temporary and permanent) will be connected to the plant for the convenience of the construction crew. In outlying areas, provision of chemical toilets will continue.

As plant piping systems are completed, they will be cleaned and tested by water flushing. This water will be collected and reused.

3.19.6.4 Sedimentation and Water Pollution Control

The problems of sedimentation and water pollution by silty storm runoff exist in most major construction projects. In site planning and preparation, WRSP will consider many measures to minimize the problem. Some of these control measures are discussed below.

- Holding Pond. A holding pond will be one of the first facilities constructed. Located at the north edge of the process area, it will be sized to collect the 100-year storm runoff from the entire process and shale stockpile area. In addition, the volume of this basin will be designed to hold a 10 percent sediment load.

The collected storm runoff will be stored and used for dust control and other general construction purposes. During plant operation, the catch basin will collect storm runoff and treated wastewater.

- Landscaping. Upon completion of construction activities, the laydown areas, spoil areas, temporary parking areas, and temporary roads and haulways that are not required for the permanent facility will be landscaped to be compatible with the original terrain.
- Stabilization. Most of the disturbed areas, such as drainage ways, cut-and-fill slopes, borrow pit areas, and excavation and soil stockpiles, will be stabilized as soon as possible as part of a total grading and vegetation program. Runoff will be intercepted and diverted wherever such erosion protection is needed.

- Impoundments. Two impoundments will contain runoff and leachate from the processed shale. The first will be the Phase I dam; the second will be the Southam Canyon retention dam, as discussed in Section 3.10.

3.19.6.5 Construction Noise Control

The amount of noise generated by construction activities will depend largely on the day-to-day schedules and the variations in equipment operation, weather conditions, etc. A preliminary evaluation was made of the construction noise level, and the results are discussed in Section 5.3.

3.20 OPERATIONS MANPOWER

A pool of operations manpower will serve mining, retorting, upgrading, and all of the support functions necessary to the project as it moves through all phases to full commercial operations.

Since mine development is a steadily continuing activity, the mining manpower grows smoothly through all project phases, until it levels off at 1,678 men at full production.

The surface plant manpower requirements increase in steps during the startup period of each phase, prior to bringing additional retorts on-line. They then level off during the full production periods of each phase.

Table 3.20-1 gives the operations manpower requirements from 1983 through the end of the project, in 6-month intervals.

Table 3.20-1

OPERATIONS MANPOWER REQUIREMENTS

Year	Number
1983	20
	35
1984	90
	165
1985	526
	738
1986	833
	833
1987	833
	863
1988	973
	1,006
1989	1,357
	1,658
1990	1,796
	1,979
1991	2,095
	2,230
1992	2,346
	2,696
1993 ^(a)	2,930

(a) After 1993, the requirement will remain level at 2,930.

3.21 DECOMMISSIONING-ABANDONMENT PLAN

Plans have been made for decommissioning-abandonment to ensure that the lease stipulations are followed, that improvements are treated properly, and that the environment is protected.

The lease provides for lease relinquishment, remedies in case of default, delivery of premises in case of default, and disposition of property upon termination of the lease (Ref. 3-13). The plan described in this section is intended to comply with the lease provisions governing actions taken after suspension of operations or termination and relinquishment of the lease by either party.

- Decommissioning. This action could occur when the lessee elects to suspend operations for further processing of shale but anticipates resumption at a later date. For example, the lessee might proceed with decommissioning at the scheduled conclusion of Phase I in Year 8. Decommissioning could also occur with the owners retaining the lease or, under conditions of relinquishment of the lease, with sale of all or part of the improvements to others.
- Abandonment. This action would occur when the lease is relinquished or terminated without sale of the permanent improvements to others. Circumstances causing abandonment would be either exhaustion of the reserve (lack of sufficient raw material for economic mining and processing) or economic or technological problems that would dictate conclusion of operations either after decommissioning of Phase I or during commercial operations in Phases II and III.

3.21.1 DECOMMISSIONING

This subsection describes decommissioning plans for the leased land and its improvements.

3.21.1.1 Preservation of the Mine and Aboveground Facilities

The mine will be maintained on a standby basis, which includes pumping to keep the mine dewatered. Mining equipment will be mothballed and stored, and mine structures and openings will be periodically inspected and maintained.

All aboveground improvements will be maintained for future recommissioning. Vessels will be cleaned out and degassed; chemicals will be removed and stored or disposed of; and equipment will be mothballed in place or stored, as necessary, using protection techniques appropriate to the expected downtime period. Inventories of products will be shipped or secured.

3.21.1.2 Maintenance of Processed Shale Disposal Area, Retention Dam, and Reservoirs

Maintenance of the processed shale disposal area, retention dikes, dams, and reservoirs will continue through the period when facilities are decommissioned. Programs of stabilization, erosion protection, drainage, and revegetation of the processed shale disposal area will proceed to realize objectives.

Wastewater and emergency runoff holding basins will be drained at decommissioning and attended thereafter as long as practical. To provide supply of fresh water and to furnish fire protection, the freshwater reservoir will continue to function at a reduced level after decommissioning.

3.21.1.3 Manpower

Decommissioning after Phase I will result in displacement or reassignment of certain personnel. After shutdown of the Phase I facilities, mine development will continue. The retort operating and maintenance personnel will be employed in construction of the commercial plant.

Decommissioning under other circumstances will result in reassignment of manpower. If the operation is expected to be resumed shortly, personnel will be retained. Personnel will be kept to service the ongoing responsibilities such as retention dam, revegetation plot, etc., as required.

3.21.2 ABANDONMENT

Abandonment of Leases Ua and Ub will follow the conditions established in the shale oil leases.

3.21.2.1 Return to a Natural State

The disturbed areas are to be restored as closely as possible to their natural state. After removal of all salvageable equipment, the shafts and mine portals will be sealed. All surface equipment and structures will be removed and the foundations taken down to grade. Disturbed areas will then be rehabilitated and revegetated to conform to aesthetic provisions of the lease, as described in Section 4.6.

3.21.2.2 Maintenance of Processed Shale Disposal Area, Retention Dam, and Reservoirs

These programs and facilities will be continued in order to minimize any adverse environmental effects and to comply with approved plans and lease terms. Subsection 4.6.2 discusses the revegetation plans for processed shale. If abandonment occurs before commercial operations, the Phase I retention dam will be raised by 5 feet to control runoff.

3.21.2.3 Manpower

The work force will be reduced gradually by relocation or termination of personnel. After abandonment has been completed, a minimum work force will be retained to deal with any residual facilities or programs requiring attention.

REFERENCES - SECTION 3

CRAIG DISTRICT OFFICE
LIBRARY COPY

- 3-1 First Year Environmental Baseline Report, White River Shale Project, VTN, Denver, Colorado, 1976.
- and
- Progress Report, Environmental Program, 1977, WRSP, Vernal, Utah, July 1978; Progress Report, Environmental Program, 1978, WRSP Vernal, Utah, July 1979; and Progress Report, Environmental Program, 1979, WRSP, Vernal, Utah, September 1980.
- 3-2 WRSP Preliminary Rock Mechanics Report, Cleveland-Cliffs Iron Company, Western Division, Rifle, Colorado, October 2, 1975.
- 3-3 WRSP Geologic Exploration Program Report, Cleveland-Cliffs Iron Company, June 30, 1975.
- 3-4 WRSP Geophysical Logging Report, Cleveland-Cliffs Iron Company, July 1, 1975.
- 3-5 Research and Development Program on the Disposal of Retorted Oil Shale, Woodward-Clyde Consultants, Denver, Colorado. (year?)
- 3-6 Cyrus M. McKell, et al., Wildland Shrubs: Their Biology and Utilization, U.S. Department of Agriculture, Forest Service, Washington, D.C., Rep. INT-1 Symposium, 1971.
- 3-7 Institute for Land Rehabilitation 1979. Selection, propagation and field establishment of native plants in arid disturbed lands. Bulletin 500, Utah State Agricultural Experimental Station.
- 3-8 Institute for Land Rehabilitation 1979. Rehabilitation of Disturbed Sites and Processed Oil Shale Disposal Areas. Final Report to White River Shale Project. Utah State University, Logan, Utah.
- 3-9 White River Shale Project, Water Supply Alternatives, Bingham Engineering, Bountiful, Utah, January 1976, p. 3.14-1.
- 3-10 "Hinderlider versus La Plata River and Cherry Creek Ditch Company," U.S. Supreme Court, Book 304, 1938, p. 92.
- 3-11 "Water Resources Data for Utah," U.S. Department of Interior, Geological Survey, U.S. Printing Office, Salt Lake City, Utah, 1975, p. 3.14-5.
- 3-12 A. Barry Crawford, et al., Socioeconomic Impact Study of Oil Shale Development in the Uintah Basin, Western Environmental Associates, Inc., Providence, Utah, November 1975.
- 3-13 Federal Oil Shale Leases, Nos. 25918 and 26194, June 1, 1974.

DATE LOANED	

--	--	--	--

